SURGERY Gynecology and Obstetrics

With International Abstract of Surgery

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The Newer Concepts of Meat in Nutrition

Meat . . .

and the Acid-Ash Diet

MAINTENANCE of urinary pH within certain limits is frequently advisable in the treatment of local conditions in the urinary tract. This may be accomplished by the administration of inorganic salts and by the institution of proper diet. In some cases both means are utilized, while in others diet alone may suffice.

A diet adequate for this purpose must be so organized in pH influencing factors that the urine will show the desired hydrogen ion concentration. Thus dietary adjustment becomes a valuable tool in the treatment of urinary tract affections.

Phosphatoptosis, with or without calculi formation, and infection with Escherichia coli are common conditions of the urinary tract in which maintenance of an acid pH of the urine is indicated. Because phosphate precipitates only in an alkaline medium, phosphatoptosis and the recurrence of phosphate concretions are prevented by holding the urine to an acid pH. Since an acid urine also is unfavorable to the growth of Escherichia coli, an acid-ash diet becomes an important instrument in therapy.

Meat is a good source of acid forming elements—chlorine, phosphorus, and sulfur. Hence it is an important constituent of the acid-ash diet. In addition, it provides the patient with biologically adequate proteins, B vitamins, and the essential minerals iron and copper.

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The Seal of Acceptance denotes that the statements made in this advertisement are acceptable to the Council on Foods and Nutrition of the American Medical Association.

American Meat Institute

CHICAGO

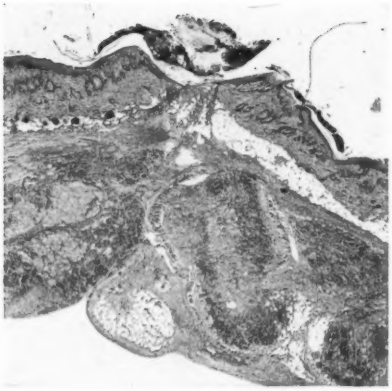
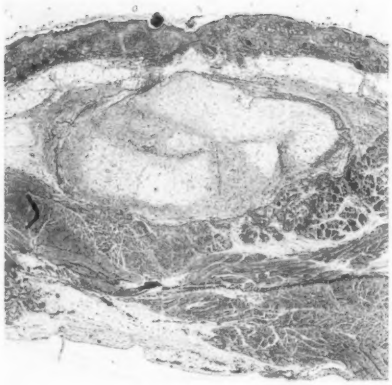


Fig. 3



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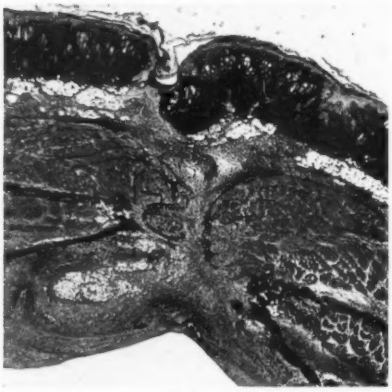

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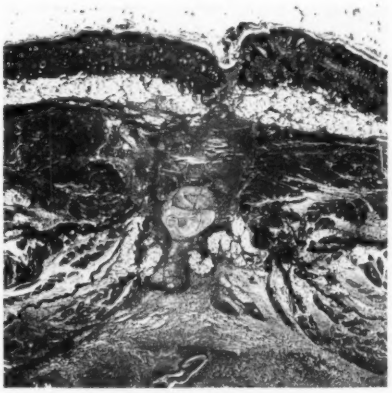

Fig. 6

Fig. 7

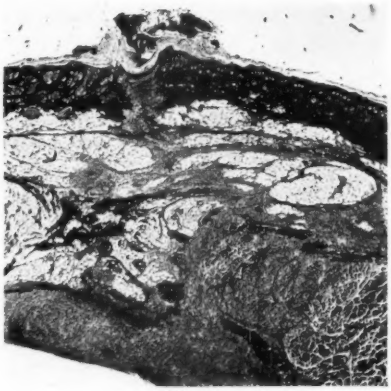

Fig. 8

The Relationship of the Concentration of Ascorbic Acid of the Blood to the Tensile Strength of Wounds in Animals.—John B. Hartzell and William E. Stone

UNIV. OF MICH.

SURGERY

GYNECOLOGY AND OBSTETRICS

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THE RELATIONSHIP OF THE CONCENTRATION OF ASCORBIC ACID OF THE BLOOD TO THE TENSILE STRENGTH OF WOUNDS IN ANIMALS

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THE healing of wounds is a complex phenomenon and cannot be described in terms of a few specific governing factors. The regulation and control of growth of tissue presents problems not understood, and since the healing of wounds is dependent on the growth of tissue the problem of healing is not easy. However, there is certain information available regarding deterrents to healing in surgical wounds in patients. Deterring factors may be classified as (1) general or (2) local. These have been discussed in recent reviews (5, 6, 10, 15).

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In order that a wound may heal it must be at sufficient rest for the parts to adhere, but many mechanical factors found in surgical patients cause motion of the approximating edges. Imperfect suturing, activity on the part of the patient, coughing, straining, or rough handling on the part of attendants disturb the quiet of the wound. Locally, excessive trauma, infection, strangulation of tissue, presence of foreign bodies, and excessive tension, are factors which predispose to poor wound healing. These have been mentioned in most discussions of the subject; that they may cause difficulty in wound healing is obvious. Other factors, especially in clean and otherwise uncomplicated cases, are usually less apparent and must be considered as due to general disturbances in the patient, since

Fig. 3. Four day wound of a normal guinea pig. Note absence of exudate and partial healing of corium. Tensile strength 183 grams per centimeter of wound. Hematoxylin and eosin. ×20.

Fig. 4. Four day wound of a deficient guinea pig. Note exudate in corium and subcutis. Tensile strength 138 grams per centimeter of wound. Hematoxylin and eosin. ×20.

Fig. 5. Six day wound of a normal guinea pig. Note collagen production throughout wound. The tensile strength of this wound was 674 grams per centimeter. Azocarmine. ×20.

Fig. 6. Six day wound of a deficient guinea pig. Note pool of exudate in muscularis. No evidence of collagen in corium. The tensile strength was 291 grams per centimeter. Azocarmine. ×20.

Fig. 7. Eight day wound of a normal guinea pig. Note abundant collagen present throughout wound. The tensile strength was 1279 grams per centimeter. Azocarmine. ×20.

Fig. 8. Eight day wound of a deficient guinea pig. Note only small amount of collagen present. The tensile strength was 345 grams per centimeter. Azocarmine. ×20.

no local or mechanical cause is known. Concurrent disease and malnutrition probably are the most important of the general causes of poor wound healing. These have until recent years received little attention.

Experimental data have shown that vitamin C deficiency plays an important part in wound healing in the experimental animal. Aschoff and Koch in 1919 stated that in scurvy the main primary deficiency is a lack of intracellular cement substance. Hojer in 1924 verified these observations in the scorbutic guinea pig and noted changes which were due to a lack of collagen. Wolbach and Howes demonstrated that the histological basis for the failure of wounds to heal in the presence of vitamin C deficiency lies in the inability of the supporting tissues to produce and maintain intracellular substance, and later Menkin, Wolbach, and Menkin found that microscopic sections of tissues of scorbutic animals demonstrated the deposition of increasing amounts of intracellular cement substance depending on the amount of vitamin C administered. Taffel and Harvey reported that the tensile strength in stomach wounds of the partially scorbutic guinea pig is much decreased from the 8th to the 10th day. Lanman and Ingalls have shown that guinea pigs maintained on approximately one-fifth of the minimal protective dose of ascorbic acid exhibited healing of operative wounds inferior to those of normal controls. Von Jeney and Törö were able to demonstrate in *in vitro* cultures of fibroblasts a sudden increase in collagen fibrils when ascorbic acid was added to the medium. Wolbach (23) states that deficiencies of vitamin C result in abnormalities of all intracellular substances having collagen as their basis, and that its absence prevents the formation of the matrices of white fibrous tissue, bone, cartilage, and dentin. He states further that in vitamin C deficiency the pathological picture is produced by resorption of intracellular materials in both growth and reparative reactions. In such instances, if vitamin C is supplied either in natural foods or as the pure compound, histological repair is immediately resumed. Some of these findings were confirmed by Mazoue. Lauber and Rosenfeld in 1938 made histological studies of the vitamin C content of various tissues in the bodies of guinea pigs on low vitamin diets. When wound healing was in progress a decreased amount of vitamin C was found in the various tissues, suggesting that it had been utilized in the healing process. In a recent experimental study, Hunt found that collagen does not form in healing wounds of guinea pigs partially deficient in vitamin C, and that the intracellular substance remains immature and of poor holding power. He concluded that vitamin C in good concentration is of the greatest importance in wound healing.

It would seem that there is ample proof, many times confirmed, that vitamin C is necessary for the formation of collagen in tissue repair, and further that the development of tensile strength in wounds is retarded by a partial or complete vitamin C deficiency.

This report is concerned with a careful biochemical and histological study of wound healing associated with deficient vitamin C intake but with other factors maintained as constant as possible.

METHODS

Young guinea pigs were used, weight 300 to 450 grams at start of the experiment. Both males and females were included, being distributed evenly in control and vitamin C deficient groups. The basal scorbutogenic diet used in all experiments was arrived at by combining features of diets used by several previous investigators (13, 19, 21). Its composition is as follows: rolled oats, 40 per cent; skimmed milk powder, heated, 30 per cent; wheaten bran, 18 per cent; butter fat, 10 per cent; sodium chloride, 1 per cent; cod liver oil, 1 per cent.

The animals were kept on this diet plus an adequate oral ascorbic acid intake of 5 milligrams a day for at least a week before the start of the experiment. The controls were continued on this regimen throughout, while the vitamin C deficient animals were given no ascorbic acid for one week and 0.2 milligram per day thereafter. (Note: 2 mgm. per day is the threshold for tooth protection, according to Harris and Ray.) The average of the weight curves was approximately the same for

Fig. 1. Abdominal wounds in deficient and control guinea pigs on the 8th postoperative day. There is marked edema about the wound of the deficient guinea pig with heavy crusts still present. This presents a marked contrast to the wound in the control animal which appears quite healed.

Fig. 2. Abdominal wounds in deficient and control guinea pigs on the 14th postoperative day. The stitches had been removed 5 days previously. There still are a few crusts present on the wound of the deficient animal and some thickening remains, while the wound of the control pig is soft, smooth and well healed.

the deficient and the control guinea pigs. Both groups gained until the day of the operation. They then showed a loss the day after operation. The downward trend was reversed from the 4th to the 6th day, after which they then continued to gain at about the same rate throughout the duration of the experiment.

The animals were operated upon 14 to 15 days after the start of the experiments. Midline abdominal incisions about 6 centimeters in length were made and sutured with silk. Nembutal anesthesia was used. The animals were sacrificed 4, 6, 8, 10, or 14 days later. Blood was obtained at this time for determination of plasma ascorbic acid and total protein. The blood was drawn from 5 to 10 hours after the last vitamin C was given. The plasma vitamin C value was determined by the method of Bessey, slightly modified. The plasma protein value was determined by the total nitrogen determination method of Pregl.

For the determination of wound strength, the entire belly wall was removed and the sutures all cut. Strips 1 centimeter in width (measured *in situ*) were cut perpendicular to the incision, by means of a sharp razor blade. The tensiometer was used to measure the grams per centimeter length of wound, as read directly from the tensiometer scale. Four or five such strips were obtained from each animal and the average calculated. Thus the average strength over the whole length of the wound may be estimated. In this respect the method differs from that used by others who measured the pressure required to burst the wound open, thereby obtaining the strength at the weakest point. For the purpose of conducting the histological studies a 5 millimeter strip was taken from near the center of the wound.

The piece of excised wound for histological study was fixed in 10 per cent formalin and paraffin sections were prepared. Routine hematoxylin and eosin and Heidenhain's azocarmine were stains used in the preparations of slides. The last mentioned stain was of some value in comparing the amount of collagen present in the wounds, but most of the changes were present with the routine hematoxylin and eosin stains. In comparing the controls and the test animals we found great variations in healing of wounds which could be ascribed to inaccurate approximation; therefore, comparisons were made of representative guinea pigs in the control group and representative guinea pigs in the deficient group.

RESULTS

There was a marked difference in the gross appearance of the wounds in those guinea pigs kept on diets rich in vitamin C and in those kept on a partially vitamin C deficient diet. This is in confirmation of Hunt's previous findings.

In the normal guinea pigs, healing progressed rapidly. The wounds were clean, there was no oozing of blood from the margins or about the sutures, and there was no edema about the wound. On section there was no thickening of the belly wall and no evidence of hemorrhage into the wound. They almost universally appeared well healed by the 6th to 8th postoperative day, and by the 10th to the 14th postoperative day the incision was white and smooth. (Figs. 1 and 2.)

In those animals fed vitamin C deficient diets, the wounds presented a very different appearance. Almost without exception there was edema along the suture lines with some redness. Heavy bloody crusts formed soon after operation and were almost invariably still present on the 8th to the 10th postoperative day. Although appearing well healed on the 14th day, the incision was still hard and raised, with some crusts still present. When the belly wall was sectioned it was found to be thickened and often presented a hemorrhagic appearance.

Microscopic study of sections of wounds in control and in partially vitamin C deficient animals were made and we are indebted to Dr. Mark E. Mann of the department of pathology for his aid in interpreting the histological data. This study revealed marked differences as early as the 4th postoperative day. In the control animal (see photomicrograph, Fig. 3, frontispiece) epithelial bridges were complete though the thickness of the epithelium varied in individual pigs. A slight exudation of serum, red blood cells, and neutrophils was found in the corium and between the muscle bundles. A moderate fibroblastic proliferation was evident in the deep portion of the corium, but only a few thin collagenous fibers could be seen. Numerous foreign body giant cells and focal collections of mononuclears were detected at the edges of the wounds. Examination of the slides of the 4 day deficient group (Fig. 4, frontispiece) revealed the epithelium to be well healed. In the reticular portion of the corium and in the subcutis numerous pools of serum containing red blood cells and a few lymphocytes could be found. Fibroblastic proliferation was more marked than in the control animals, but collagen production was scant. The presence of a hemorrhagic effusion was constant in all deficient animals.

At 6 days the wounds of control animals (Fig. 5, frontispiece) indicated progressive healing by an increase in fibroblastic proliferation; the production of some mature collagen and of numerous thin blue-staining fibers was noted in the azocarmine stain. Collagen production appeared most marked in the corium but was almost as abundant in the muscle layers. At 6 days the wounds of deficient guinea pigs (Fig. 6, frontispiece) showed a marked exudation of fluid containing red blood cells; the exudate was seen throughout the entire extent of the wound but was most marked in the reticular layer of the corium and in the subcutis. Proliferation cells were as numerous in deficient animals as in control animals, but collagen production was definitely retarded. We were unable to detect any differences in cellular proliferation about the muscle fibers or any increase in the number of giant cells.

Striking differences in collagen production were evident when the wounds of control guinea pigs were compared with the wounds of deficient animals 8 days after operation. In many instances the wounds of animals in the control group (Fig. 7, frontispiece) were found to be almost completely replaced by mature collagen, while the wounds of deficient animals (Fig. 8, frontispiece) showed only small areas of collagen production. A marked proliferation of fibroblasts was evident in the deficient guinea pigs and only a moderate proliferation in the controls. The wounds of almost all deficient animals showed small pools of serum and red blood cells separating the wound edges. These pools were usually present in the deep layers of the corium but could be found throughout the entire wound.

At 10 days the wounds of the control group showed collagen production continued beyond that of 8 days. The wounds of deficient

animals likewise showed at 10 days a marked increase in the amount of collagen present, and, furthermore, a decrease in fibroblastic proliferation. Only by careful examination could small pools of exudate be detected in the specimens from the vitamin C deficient animals. These pools were usually found in the corium. In both the control and the deficient groups the amount of cellular débris and of foreign body reaction was markedly diminished.

In the slides of the 14 day groups there was wide variation in the amount of healing. In the majority of the control animals the wounds were almost completely healed and showed some contraction. The wound sites were difficult to detect in the corium, for the collagen was dense and the fibrocytes apparently mature. In the muscle layers a large amount of collagen was present with only a mild cellular proliferation. In deficient animals at 14 days, good wound repair was seen in some, but in many the wounds gaped at various levels. Little effusion could be seen, but marked cellular proliferation was present in most instances. The amount of collagen present, judged by azocarmine stain varied with each animal; the maximum production was usually found in the corium.

In animals deficient prior to operation but given ascorbic acid daily after operation, it was found that healing was delayed during the first 6 days. Small effusions were found in some animals, and collagen production was postponed in all. By the 8th day after operation however, the wounds appeared almost as completely healed as those of the control group.

The plasma vitamin C levels found in normal animals are lower than those reported for guinea pigs by various other workers, who, however, used titration methods. According to King the lower values are more nearly correct. This method has been in use continually in the laboratory for specimens from human patients, and gives results in the normal range (0.5 to 2.0 mgm. per 100 c.c.) when no deficiency is present. A small series of unoperated upon control animals gave results not significantly different from those for the operated upon animals. All the normal guinea

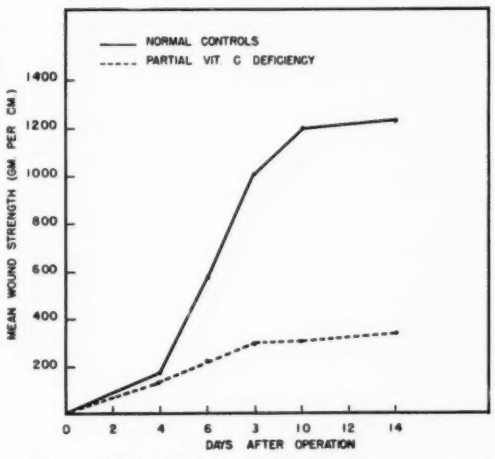

Fig. 9. Effect of partial vitamin C deficiency on wound healing in guinea pigs. The unbroken line represents the average of the tensile strength of 1 centimeter of wound in the 60 guinea pigs fed adequate amounts (5 to 10 mgm.) of ascorbic acid daily. The broken line represents the average tensile strength of 1 centimeter of wound in the 40 guinea pigs fed deficient amounts (0.2 mgm.) of ascorbic acid daily.

pigs had values above 0.05 milligram per 100 cubic centimeters, with two exceptions, and all those with deficiency had values below 0.05 with one exception.

Vitamin C intake	Plasma vitamin C
10 mgm. a day	0.22 (average of 20)
5 mgm. a day	0.13 (average of 40)
0.2 mgm. a day	0.01 (average of 40)

The average plasma protein for 60 normal guinea pigs was 4.63 per cent and for 40 partially deficient guinea pigs it was 4.55 per cent. It is seen there is no significant difference between the two groups. The values are normal for guinea pigs (8). Therefore, the lower tensile strength of the wounds in the guinea pigs fed the partially vitamin C deficient diet is not due to decreased plasma protein.

Moisture determinations on segments of the abdominal wall were made after the tensile strength had been determined in a few cases. For 7 normal animals the average was 76.1 per cent ($\pm$2.1 per cent) and for 6 partially vitamin C deficient animals the average was 79.1 per cent ($\pm$1.7 per cent). Only 1 of the deficient animals gave a result lower than the highest control.

TABLE I.—EFFECT OF PARTIAL VITAMIN C DEFICIENCY ON TENSILE STRENGTH OF WOUNDS IN GUINEA PIGS

Number of guinea pigs	Amount of vitamin administered		Tensile strength of wound in grams per centimeter				
	Ascorbic acid mgm. per day	Citrin mgm. per day	On 4th P.O. day	On 6th P.O. day	On 8th P.O. day	On 10th P.O. day	On 14th P.O. day
20	10	0	169	474	1158	1223	1129
20	5	0	189	602	1045	1198	1490
20	5	2	174	577	812	1177	1379
20	0—14th to 7th preoperative day. 0.2 mgm. thereafter	0	105	240	315	283	367
20	0—14th to 7th preoperative day, 0.2 mgm. thereafter	2	173	205	291	329	317
10	0—14th to 7th preoperative day, 0.2 mgm. to operation. 10 mgm. thereafter	0		310	909	1235	

The tensile strengths of the wounds in the guinea pigs kept on the vitamin C deficient diet and in the control animals showed a marked difference from the 6th day on. On the 4th postoperative day the differences were not significant. On the 6th day, however, the wounds of the control animals were more than twice as strong, and by the 10th day had become four times as strong as those of the deficient animals (see Fig. 9).

A study of Table I will reveal that there is no significant difference in the tensile strength between those animals kept on the daily dose of 5 milligrams of ascorbic acid, which is adequate for a guinea pig, and those kept on 10 milligrams daily, which may be considered excessive dosage.

In the last line of Table I data are presented from a group of animals which received the usual deficient amount of ascorbic acid until the time of operation. On the day after the operation they were given 10 milligrams of ascorbic acid and from then on received a daily dose of 10 milligrams. On the 6th postoperative day the tensile strengths of the wounds of these animals, while not as great as those in the control guinea pigs, were definitely above those in the deficient animals, and by the 8th postoperative day had attained the level of the controls.

The graph summarizes the results. The heavy unbroken line represents the average for the 60 guinea pigs fed adequate (5 or 10 mgm.) ascorbic acid and the broken line represents the average for 40 guinea pigs fed 0.2 milligrams of ascorbic acid daily. Each point on the unbroken line is the average for 12 animals. Each point on the broken line is the average for 8 animals. The normal wounds reached the strength of the unoperated abdominal wall by the 14th day. However, they frequently broke through elsewhere than at the wound after the 8th day. The wounds in the deficient guinea pigs always broke at the incision. The strength of the unoperated upon abdominal wall is the same in control and in deficient animals, being somewhere between 1200 and 2000 grams per centimeter.

Several normal animals were allowed to heal for 2 weeks (5 or 10 mgm. vitamin C per day). At this time the wounds were well healed. The vitamin C was then withdrawn completely, and the animals were allowed to develop scurvy of more or less severity. They were sacrificed after they had been losing weight for several days. The wounds appeared grossly to be in poor condition, with the characteristic hemorrhagic appearance, but had normal strength. Only 3 animals survived for completion of the experiment.

Sections of tissue from 2 guinea pigs sacrificed on the 20th and 22nd days following withdrawal of vitamin C showed the wounds to be well healed and comparable to those of the control animals. The tensile strengths of their wounds were 1248 and 1401 grams per centimeter of wound. The wound of the third guinea pig sacrificed on the 34th day after withdrawal of vitamin C contained a pool of serum between the muscle layers, and there was no appreciable decrease in the amount of collagen. This wound appeared comparable to those of the 8 and 10 day deficient animals, and had a tensile strength of 880 grams per centimeter of wound.

Addition of 2 milligrams per day of lemon eriodictin to the diet of either normal or partially vitamin C deficient guinea pigs had no significant effect on wound healing. (Table I). This substance is Szent-Györgyi's "vitamin P" or citrin, a flavone glycoside. It is claimed

to be useful in treating vascular forms of purpura (12), and Szent-Györgyi (3) and his associates attributed the hemorrhagic symptoms in scurvy to a deficiency of citrin. (The basal diet used in these experiments may not be entirely free from this substance). An attempt to study the capillary fragility by the method of Zacho gave somewhat erratic results, but indicated no difference between normal and partially vitamin C deficient animals or between those receiving lemon eriodictin and those not receiving it.

SUMMARY

Wound healing was found to be retarded in guinea pigs kept on a subscurvy diet. The tensile strength of wounds in these animals was about one-half normal on the 6th postoperative day and about one-quarter normal from the 8th through the 14th day.

Increasing the vitamin C dosage above the normal daily requirement did not result in greater than normal development of tensile strength in wounds.

In animals operated upon while in a subscurvy state and given a high vitamin C dosage after operation, the wounds reached the same degree of tensile strength as in normals by the 8th postoperative day.

Addition of lemon eriodictin (citrin, "vitamin P") to the diet did not improve the wound healing process in either normal or partially vitamin C deficient animals.

Histological studies showed that the low tensile strength in wounds of partially vitamin C deficient animals was due to a failure of collagen production.

REFERENCES

1. Aschoff, K. A. L., and Koch, W. Scorbut: Eine pathologisch-anatomische Studie. Jena: Gustav Fisher, 1919.
2. Bessey, O. A. J. Biol. Chem., 1938, 126: 771.
3. Bruckner, V., and Szent-Györgyi, A. Nature, Lond., 1936, 138: 1057.
4. Harris, L. J., and Ray S. N. Biochem. J., Lond., 1933, 27: 2016.
5. Hartzell, J. B., and Winfield, J. M. Surg. Gyn. Obst., Internat. Abstr. Surg., 1939, 68: 585–601.
6. Hartzell, J. B., Winfield, J. M., and Irvin, J. L. J. Am. M. Ass., 1941, 116: 669–674.
7. Höjer, J. A. Acta paediat. (supp.), 1924, 3: 8–278.
8. Howe, P. E. Physiol. Rev., 1925, 5: 439.
9. Hunt, A. H. Brit. J. Surg., 1941, 28: 436.
10. Jenkins, H. P. Surg. Gyn. Obst., 1937, 64: 648.
11. King, C. G. Personal communication.
12. Kugelmass, I. N. J. Am. M. Ass., 1940, 115: 519.
13. Lanman, T. H., and Ingalls, T. H. Ann. Surg., 1937, 105: 616–625.
14. Lauber, H. V., and Rosenfeld, W. Klin. Wschr., 1938, 17: 1587–1888.
15. Mason, M. L. Surg. Gyn. Obst., Internat. Abstr. Surg., 1931, 69: 303–315.
16. Mazoue, H. C. rend. Soc. biol., 1937, 126: 991–992.
17. Menkin, C., Wolbach, S. B., and Menkin, M. F. Am. J. Path., 1934, 10: 569–575.
18. Pregl, F. Quantitative Organic Microanalysis. 3d ed. Translated by E. Beryl Daw. Philadelphia: P. Blakiston's Son & Co., 1937.
19. Sherman, H. C., LaMer, V. K., and Campbell, H. L. J. Am. Chem. Soc., 1922, 44: 165.
20. Taffel, M., and Harvey, S. C. Proc. Soc. Exp. Biol., N. Y., 1938, 38: 518–525.
21. Todhunter, E. N., and Brewer, W. Am. J. Physiol., 1940, 130: 310.
22. Von Jeney, A., and Törö, E. Virchow's Arch., 1936, 298: 87–97.
23. Wolbach, S. B. J. Am. M. Ass., 1937, 108: 7–13.
24. Wolbach, S. B., and Howes, P. R. Arch. Path., 1926, 1: 1–24.
25. Zacho, C. E. Acta path. microb. scand., 1939, 16: 144.

FREE FULL THICKNESS SKIN GRAFTS

Principles Involved and Technique of Application

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THE advantages of transferring skin by means of free grafts rather than by tedious flap operations are obvious. In many circumstances it is imperative that flaps be used because the conditions under treatment require the transfer of a greater thickness of tissue than that possible by free grafts or because this is definitely the method of choice. The objections to the use of flaps (provided a better method is available) are the time period often required from beginning to completion of a repair, the number of operations necessitated, sometimes objectionable scarring of relatively exposed portions of the body, the chance of losing hard earned tissue from circulatory insufficiency after prolonged preliminary steps, the limitation of the available surface area practical to transfer, the sometimes "heaviness" of the transferred tissue which is at best difficult to eliminate (Fig. 1), and perhaps most disappointing of all, the possibility of discovering, after a long series of preliminary operations, that the area of the flap is inadequate. In dealing with many of the defects often treated by the use of flaps, the surgeon would gladly substitute free grafts of part or whole thickness skin if he had adequate confidence in his ability to get successful "takes" of the grafts.

For practical purposes, free grafts, other than pinch grafts, may be divided into two groups: those involving part thickness of the skin (Thiersch, split, intermediate thickness, etc.), and those involving the complete thickness of the skin but not including any of the underlying tissue.

The problem of choosing the type of graft to be used must be settled by the operator's experience and judgment, the final selection often being made at the operating table. It is possible, however, to state some rules for this choice as well as some advantages and disadvantages of each type of graft.

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THE SPLIT THICKNESS GRAFT

It is well to realize that the split thickness graft is not necessarily the tissue-paper-thin, ragged graft obtained in small scraps as often seen. It is possible to obtain it at will, given reasonable skill in cutting and a reasonable donor site, ranging in thickness from one-half the total depth of the skin to almost full thickness. A graft 12 inches long and 4 inches wide can often be obtained, and on one ideal subject grafts have been taken in one piece 30 inches long, the donor area extending from the scapula to the knee on the posterior body surface. The advantages of this type of graft are: (1) It takes very readily. (2) It may be applied, with confidence, to an open ulcerating wound which has been properly prepared. (3) It may be obtained very quickly. (4) Any available flat surface of the body may be used as the donor site. The thighs are the easiest sites for cutting, but the abdomen, buttocks, back, and upper arm are often used. (5) The donor site heals quickly, usually being completely epithelized in 14 days. (6) If necessary, the same donor site may be used again after several months; this site for subsequent grafts is not as desirable as a fresh area but has, of necessity, in certain cases supplied three crops of skin. (7) The graft may be applied with relative speed. (8) Large areas of skin may be grafted at one operation.

The disadvantages are: (1) *Contraction and wrinkling.* If applied on a freshly created wound which is not underlaid with a rigid base, the graft will undergo a great deal of contraction and wrinkling. If the area so grafted is acted upon by strong muscle action such as in the axilla, arms, legs, etc., this contraction will relatively quickly be overcome and the wrinkling disappear (Fig. 2). In other

Fig. 1. "Heaviness" may often result from the use of flaps in an attempt to relax contractures or replace skin. The preoperative photograph shows the patient after the application of three flaps to the neck and chin. Our operative plan included the use of as much of this material as possible since it was already present; consequently the neck flaps were thinned and left in place and were supplemented with a small area of skin graft. It was our opinion, however, that the flap on the lower lip and chin could never be thinned enough to reproduce the normally thin covering of this area, so this was replaced with a free full thickness graft from the thigh as shown.

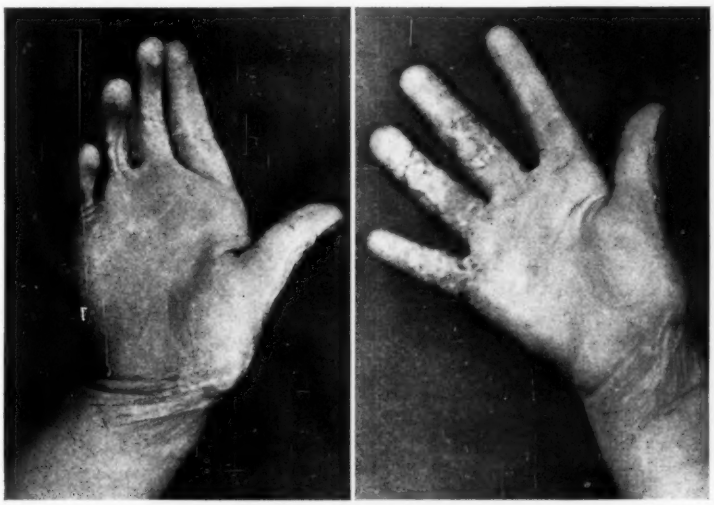

Fig. 2. It is especially important to use full thickness skin on the flexor surface of fingers. Split skin grafts tend to contract considerably more than do full thickness grafts and this coupled with the anatomical fact that the flexor muscles are much more powerful than their opposing extensors often causes a partial return of the flexion deformity. This permanent contraction is less likely to happen when a split graft is used on the dorsum of a hand, because here the tendency for the graft to contract is opposed by the powerful flexor muscles. Full thickness grafts are shown 2 weeks after application; full correction of the deformity has been maintained.

areas where the graft is closely applied to muscle which is constantly exerting a pull on the graft, the same effect is obtained. The eyelids are an example of this. If applied to a freshly denuded wound on an akinetic area, such as a cheek or neck, the result is apt to be disappointing. Oftentimes, the eventual result will be good, but several years may be required for sufficient relaxation to develop. If applied to a wound created by removal of the surface epithelium or granulations overlying a firm scar base, this wrinkling is minimized.

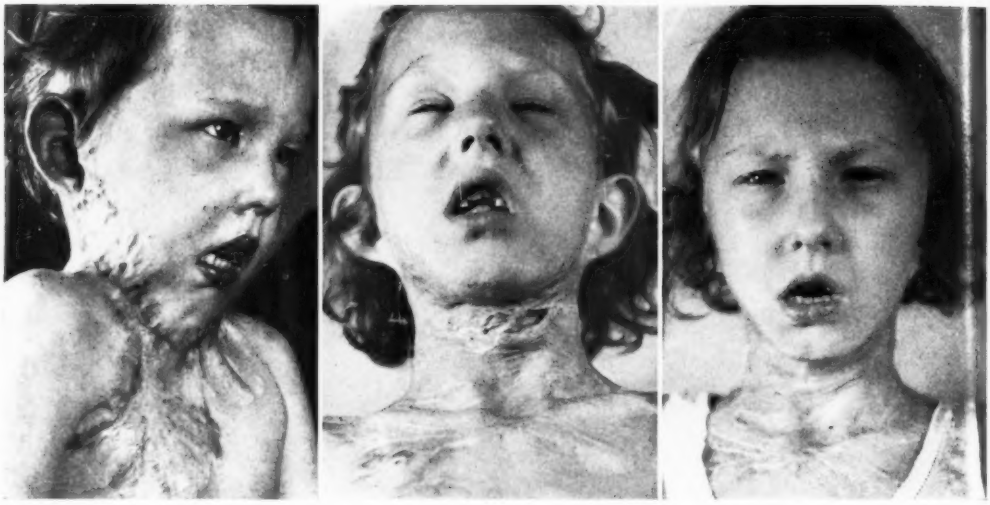

Fig. 3. In extreme deformities such as this, full correction cannot be done in one operation, and it is seldom practical to make the entire correction by the use of full thickness grafts. This deformity was relaxed and covered with split skin grafts in two grafting operations. As usually occurs on the neck, an area of this graft remained very rough and corded, although the take was as good in this area as elsewhere. This is shown in the middle photograph. The final photograph shows correction after a full thickness graft had been applied to replace and supplement the rough split graft. Split graft operations were done by Dr. V. P. Blair.

Fig. 4. Many small blemishes about the face are too large for excision and suture, and in these cases the full thickness graft of postauricular skin is near ideal. In this patient, two areas of scar tattooed with road dirt and oil, one on the upper lip and one on the left upper cheek, were excised and such skin grafts applied. The grafts are shown 6 months after operation. Grafts of this size and type can be applied with near certainty of "take."

2. *Failure to match surrounding tissue in color.* The graft may become deeply pigmented or may lose its pigmentation. Oftentimes this contrast is accentuated by tanning from ultraviolet rays. However, the surface of the graft is such that it readily takes cosmetics, after its preliminary roughness disappears, and the color may be so matched to the surrounding parts. Likewise, tissue transplanted by a pedicle flap frequently has the wrong color if taken from any part of the body other than the forehead and applied to the face. The skin color of the face contains red tones lacking in other parts of the body.

THE FULL THICKNESS GRAFT

The advantages of the full thickness graft over the split graft are: (1) It undergoes slight contraction and no wrinkling. This contraction relaxes in a few months, usually quicker

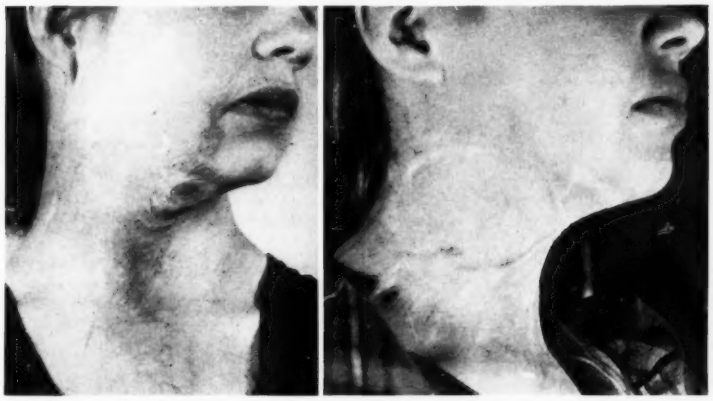

Fig. 5. This case well illustrates the deformity of features which may result from a scar pull somewhat remote from the feature itself. Note the pulling down of the lobe of the ear, the corner of the mouth and the cheek itself. This pull on the cheek frequently results in a lower position of the lower eyelid and gives the involved side of the face a pathetic expression. Considerable relaxation resulted from incision across the scar and dissection without removal of any epithelium whatever. This relaxation is shown in the postoperative photograph taken 6 months after the insertion of a full thickness skin graft from the thigh.

Fig. 6. A free full thickness graft taken from the inner surface of the upper arm and used to replace tattooed skin of the lower lip, chin, and cheeks. Below and just external to the right angle of the mouth is a scar on the graft representing an area of loss due to a small hematoma. Just below the lip border and to the left of the midline are the marks resulting from small areas of superficial erosion. Postoperative photograph taken 6 months after application of the graft. In such sites as this, the application of a pedicle flap is likely to result in too much "heaviness" in appearance (Fig. 1).

than with a split graft. (2) The resulting surface often has a better appearance and texture.

The disadvantages of the full thickness graft are: (1) It is more difficult to secure uniform "takes" than with the split graft. (2) For this reason the surface area which may be transferred at one operation is limited. (3) Its removal creates an open wound at the donor site which does not heal spontaneously by skin regeneration as does the donor site of the split graft. This open wound can sometimes be sutured; if not, it is our custom to cover it immediately with a split graft. (4) It cannot be applied to ulcerating wounds with any degree of confidence. (5) It is slow and tedious to take from its donor site. (6) It is tedious to apply and requires much more exacting care both in its first and subsequent dressings than does the split graft. (7) The color of the full thickness graft, as the color of a flap or split graft, may not match. The postauricular skin, if a small graft only is needed, usually approximates the face skin in color because it contains the necessary red skin tone.

Factors influencing "take" of full thickness grafts. The technique and uses of the split graft have been covered in other publications. The foregoing summary has been given merely

Fig. 7. The preoperative condition was represented by a thin, slick scar of the cheek. The scar, because of its texture, would not take cosmetics. In addition, due to its contraction, there was a flatness of the cheek. The middle photograph shows the wound 3 weeks after the removal of the scar thus permitting the wound to expand, and the application of a full thickness graft from the thigh. Along the anterior border of the graft is an area of loss resulting from a small hematoma. Just above its center is an area of superficial erosion resulting from intrinsic infection of the graft.

The photograph on the right was taken 6 months after operation with the patient wearing "cover-mark." The roughness of the scar from the areas of loss is shown. This may be expected to improve with time. The contour of the face was considerably improved.

to clarify terminology and to point out certain characteristics of different grafts so that the proper selection of the type of graft to be used may be made. A point of emphasis is that a split thickness graft should be used in preference to a full thickness graft unless there is a distinct reason to use the more difficult graft (Fig. 3).

General factors. It is essential that the patient's condition of general health be as good as it is possible to obtain before operation. Operation should be definitely postponed in the presence of any pus, infection of the skin, or any acute respiratory infection. In the face of general debilitation, it may be better judgment to substitute a simpler, quicker, split graft repair, with the idea of later reoperation, if necessary, with the use of full thickness grafts (Fig. 3).

Size of graft practical to apply. Small full thickness grafts "take" much more readily than do the large ones (Fig. 4). Important reasons for this are the greater ease with which a small volume of skin may be nourished by osmosis and diffusion of gases and salts while developing its blood supply, and the greater

Fig. 8. Contracture of neck and cheek resulting from an acid burn. A great deal of keloid scar was present. Such keloids may result entirely from infection of the primary wound and the irritating effect of tension on the resulting tight scar. This was true in the case in Figure 14. In addition to the factors mentioned this patient seemed to have an inherent tendency to form keloid scars. Three full thickness grafts are shown. Multiple grafts were necessitated by the purse-string contraction of the scar borders of the grafts reducing their area. Note the effort which has been made to prevent a vertical scar on the front of the neck.

Fig. 9. Illustrating the successful application of a full thickness skin graft to the inside of a nostril to replace lining of the nostril previously lost by infection. The contraction of the scar had pulled the alar border up in a notch as shown and caused considerable diminution of the breathing space. By dissection of the scar the alar border was brought down in place. A full thickness graft of postauricular skin was carefully sutured in the defect within the ala; the interrupted sutures were left long enough to tie over a gauze form to produce the proper pressure and tension on the graft. There was a full take of the graft with correction of the deformity as shown. Photographs taken 6 months later revealed no further contraction of the area.

The application of a split thickness graft here simply by the packing into the nostril of a large square of skin in "tent" fashion would have been much more simple, but the tendency of such a graft to contract afterward would probably have given an unsatisfactory final result. Postauricular skin was chosen because its thinness makes its "take" more certain.

facility with which it may develop a blood supply. Another factor is the increasing difficulty with the larger graft of fulfilling the other technical requirements of smooth recipient bed, uniformly thin skin for the graft, accurate application of the graft and proper fixation after application. Thus, on the neck, a graft of moderate size may be applied with excellent chance of success. If this graft is made larger, one border may run from the neck up over the body of the mandible and its end may cross the constantly moving thyroid cartilage, thus adding some additional hazard (Fig. 5). It is sometimes better to apply two grafts at separate operations rather than to attempt too much at one. Occasionally a contracted wound will open up to unexpected proportions or the relaxation will necessitate a rougher recipient base than is desirable for a full thickness graft. In such circumstances it is better to apply a thick split graft, later supplementing or even replacing a part of this with a full thickness graft if necessary (Fig. 3). A graft which is too large to apply to one area with certainty of "take" may not be too large for another. For example, the dorsum of the hand, wrist, and forearm represents a sizable area, but it is smooth and regular and a large graft here may be expected to do better than one of the same surface area applied to the front of the neck and covering the thyroid cartilage, the supraclavicular depression, and extending down over a movable clavicle.

Recipient site. The area to be grafted normally results from one of two procedures. It may be the defect created by the removal of

Fig. 10. Scar contracture causing considerable distortion and tightness of left upper lip and cheek. Vermilion border of left upper lip was pulled up to the level of the ala. The remainder of the scar of the face was of fair quality and could be adequately disguised by the use of "cover-mark." The contracture of the lip was dissected free and thoroughly relaxed, thus removing some surface scar. The defect was filled with a free full thickness graft of thigh skin. Patient is shown 4 months after operation wearing "cover-mark" to match the graft to surrounding skin color.

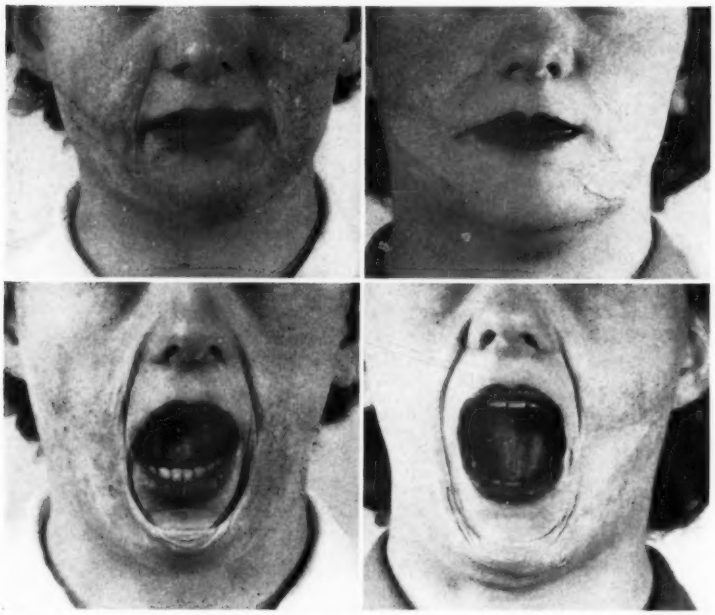

Fig. 11. This represents a very difficult problem as to proper procedure. There is generalized scarring and tightness of both cheeks, emphasized especially in the open mouth photograph. Instead of an attempt being made to replace the scar widely, an insert of full thickness skin was placed across the chief line of tightness on each cheek; actually very little of the surface scar was replaced. This operation gave considerable relaxation of the face and improvement in appearance. A wider replacement of surface scar and larger graft might have given a better result. Patient is photographed wearing "cover-mark" to match the graft to the surrounding skin color.

some pre-existing lesion such as a portwine stain, hair-bearing mole, or surface scar (Figs. 6 and 7), or it may occur as a result of incising and relaxing a contracture (Figs. 5, 10, 11, 12, 13). In either case the base of the wound should be dissected so as to be smooth, without pits and holes, thus permitting all parts of the under surface of the graft to be in contact with raw surface with the minimum of crevices to harbor small hematomas. The borders of the defect should be so trimmed as to be fairly regular inasmuch as irregularities make more difficult the accurate fitting of the graft. It is of the utmost importance that hemostasis be complete, bleeders being ligated with No. 000 or finer silk, never with catgut. The shape of a recipient wound is often important in determining ultimate smoothness of the graft. A graft applied to a movable surface should not have a straight border along the line of tension because a prominent, irritated, and contracted scar is likely to develop. The graft border should especially not extend straight down the neck (Fig. 8). This principle is well known and understood in planning operative incisions but may be overlooked in applying grafts.

Donor site. Little is definitely known about the mechanism whereby a graft assumes its own circulation. It is known, however, from the transplantation of refrigerated skin and from survival of entire extremities[1] after periods of reduced metabolism produced by long applied tourniquets and local refrigeration that tissue may have an indefinite period during which it receives very little nourishment and still survives provided the circulation is established within the dead line. It is logical to assume that there is a period following the application of a graft when it is

[1]Allen, Ann. Surg., 1938, 108: 1088

Fig. 12. This represents one of the most difficult types of cases to handle because much of the disfigurement present is due to generalized scarring of the skin, the skin being of fair quality and not involved in any marked contracture. The forehead and right cheek illustrate this point. Sometimes it is difficult to decide whether a better or poorer ultimate result would follow widespread replacement of this scarred skin. In the case here illustrated, the contracture producing the ectropion of the lower eyelid was relaxed and a full thickness skin graft of postauricular skin applied. The contracture of the left upper lip was relaxed by dissection, some of the scar of the left cheek excised, and the defect filled with a full thickness skin graft from the thigh. A better result could have been obtained if more scar adjacent to the nose had been excised and a larger graft inserted.

Fig. 13. Moderate neck contracture from a burn scar. This had previously been grafted unsuccessfully. The scar was excised and the wound relaxed by dissection. The defect was covered with a full thickness skin graft from the thigh. There was an area of loss the size of a five-cent piece near the lower border of this graft in the midline of the neck. This resulted from a small hematoma. The area was covered with a split graft 3 weeks after the first operation and left very little scar. The postoperative result is shown 1 year later.

entirely deprived of nourishment. Following this there must be another period during which it receives some nutrition from its base by osmosis and diffusion of carbon dioxide, oxygen, and blood salts. Subsequently, the blood vessels from the base gradually unite

Fig. 14.

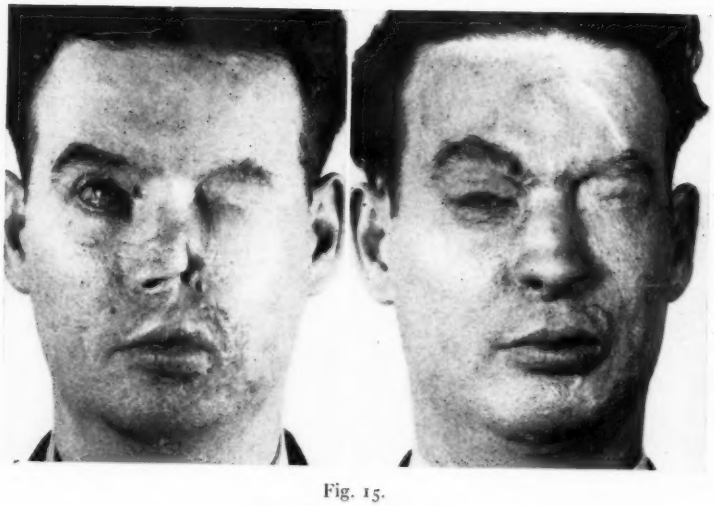

Fig. 15.

(*Legends on opposite page*)

with those of the graft. From this reasoning and from clinical observations indicating that small grafts and thin grafts take with the greatest degree of readiness, it is obvious that certain types of skin are more desirable for grafting than others (Fig. 9). For small facial grafts the very thin postauricular skin is ideal (Figs. 4 and 15). A larger area of skin can be removed from the back of the ear and the wound sutured without visible deformity than would seem possible on first thought. Occasionally it is desirable to take a depleting

amount of postauricular skin, replacing it with a split graft. The next most desirable site, from the standpoint of skin which is very thin and free from hair, is the inner surface of the upper arm (Fig. 6). The available skin is limited in area, however. The donor site most practical for the average graft, combining the desirable features of thin skin, relative freedom from hair, at least in the female, and availability, is the groin overlying Poupart's ligament and inner upper adjacent thigh. In choosing a donor site, the operator may pinch the skin up between the thumb and finger until the thinnest portion is found. The lower thigh, upper abdomen, and the back are covered with such thick skin that it is usually better to use a very thick split graft rather than expect whole skin of such thickness to develop a system of nutrition adequate to preserve itself.

Removal of the graft from its donor site. A pattern of the area to be grafted is accurately cut from a thin sheet of lead or tinfoil. This pattern is then marked out on the donor site, alcoholic methylene blue or some other such ink being used. The graft is marked out by an incision just through the derma; the skin removal is started by carefully undercutting the border with a very sharp knife. Although desirable to traumatize the graft as little as possible, it is sometimes helpful to grasp its borders carefully with mosquito forceps and hold the graft on tension until enough skin has been freed so that it can be grasped between the fingers and kept taut for dissection. A very sharp knife must be used, cutting clean and not permitting oneself to succumb to the temptation to scrape with a sidewise motion of the blade. The graft must be cut thin, the whole thickness of the skin but nothing more being taken. It is impossible to avoid an occasional tiny fleck of fat on the graft but this should be minimized. Likewise, the defect left will have numerous flecks of derma on its surface. Near full thickness grafts cut with the razor or graft-knife take with almost the readiness of thinner split grafts. From this it would seem that the more even and smooth the under surface of a graft the better its chance of take. It is of advantage to keep the graft under constant even tension during its removal, frequently sponging, with clean gauze each time, from the graft to the wound so as to keep the point of dissection white and free from blood stains and improve vision and accuracy of cutting.

Application of the graft. The graft must be meticulously applied, the edge being sutured to skin edge if possible. The graft must be under uniform tension amounting to that of normal skin tension or a little greater, never less. It must allow for the surface contour of its bed, never being tight enough to bridge a depression. It is desirable to stitch with interrupted sutures, the operator adjusting tension by trimming borders if necessary as he progresses. It is possible for relatively few interrupted sutures to be employed, the attachment being completed with a running suture of fine silk.

Application of primary dressing. This is as important as any single factor in the success of the graft. Many variations of the dressing are permissible and even necessary to meet the needs of the particular area. However, there are certain rules which must be followed. Dental compound is used by many with good results, but for small, simple grafts it is not necessary, and for large, complicated ones it is inadequate.

Fig. 14. Heavy scars resulting from a fire burn. In this case the keloid apparently was the result of infection in the wound and the irritating effects of tension on the tight scar because there was no tendency for keloids to form following the grafts. Repair was made by applying a free full thickness graft of postauricular skin to the left side of the nose, a full thickness graft from the thigh to the left upper lip and a third to the lower lip, cheek, and neck. The patient is shown approximately a year after operation and is photographed wearing "cover-mark" to match the grafts to surrounding skin color.

Fig. 15. The preoperative condition resulted from a burn with hot acid. There was an ectropion of the lower eyelid and almost complete inability to close the upper eyelid which was markedly deficient in skin and tied to the nose with scar. The left ala and columella were completely missing, and the tip of the nose was healed down to the stump of the columella. The left cheek and upper lip were considerably scarred and contracted and the left angle of the mouth hidden with scar. The patient is shown after the reconstruction of the nose from a forehead flap and the application of four full thickness skin grafts. Grafts of postauricular skin were inserted in both the upper and lower eyelids. A full thickness graft from the thigh was inserted in the upper lip, cheek and lower lip as shown. The forehead defect resulting from the use of the forehead flap was covered first with a split thickness graft which did not give a good appearance; this was then replaced with a full thickness graft from the thigh.

Next to the graft is smoothly applied fine meshed gauze impregnated with 4 per cent zeroform in vaseline or 1:2000 merthiolate ointment. There is sufficient ointment uniformly distributed to fill the interstices of the gauze, an excess is carefully avoided, and maceration does not result under these circumstances. Next to this may be placed several layers of dry gauze, with care to avoid wrinkles and folds resulting from one piece of gauze overlapping another. Instead of this dry gauze, it is often better to strip thin smooth sheets of cotton from a pad sterilized as it comes from the roll, the pad being moistened without wadding. These moist cotton sheets have a more smooth uniform surface than does gauze, and when applied next to the greased gauze layer covering the graft have fewer irregularities and wrinkles. An additional advantage is that the small amount of postoperative bleeding after impregnating the moist cotton and drying, forms, with the cotton, a very firm splint, much like crinoline. Next is applied a padding of gauze or machinist's waste and sea sponges. The dressing is bulky enough to help splint the area and it is applied with pressure. The exact and optimum pressure to be applied is unknown, and if it were known the difficulties in applying and maintaining this exact pressure would render the performance inaccurate when dressing difficult areas. It is possible to apply too much pressure, causing ischemia, when dressing a graft against such a surface as a skull, leg, or arm, on other areas it is difficult to apply too much pressure. However, it is desirable to have a firm, springy pressure dressing and anything over and above this cannot be of further value and may be harmful. Wrinkles in gauze or coarse folds of overlapping gauze are carefully avoided.

Over eyelid grafts, small grafts on the face, and often large neck grafts, primary fixation is obtained by applying exactly the same type of dressing but leaving the interrupted sutures long enough to tie over the dressing pad (Fig. 9). Care must be taken not to tie these too tightly because the tension and pressure may become too great. This type of dressing is usually supplemented with additional overlying bulk and supportive dressings.

It is of great importance not to create a defect with a part of the body in an exaggerated position, apply a graft, and then fail to maintain the part in this same position during the application of the dressing and for the next week. If, for example, a neck contracture were liberated, the head gradually being turned into a position of overcorrection, the graft applied, and then the head allowed to assume its normal position, all of the carefully executed factors for pattern, tension, and accuracy of fit would be negated. If a part is to be held in a position of exaggeration, this must be assured by the dressing, plaster-of-Paris being used if necessary, or, for hands, a previously arranged wire or aluminum splint.

It is desirable to have the grafted area as completely at rest as possible. Thus, if a graft overlies the thyroid cartilage, the swallowing movements can be minimized by nasal tube feedings; if on an extremity, neighboring joints are immobilized.

Subsequent dressings. A great deal of harm can be done to a graft if it is not dressed soon enough. Small grafts such as those applied to the eyelids, can be safely dressed on the fourth day if there is any real reason to do so, such as irritation of the covered eye. With this exception, all full thickness grafts are dressed on the fifth or sixth postoperative day. By this time the graft has definitely developed its circulation and it is entirely safe to expose it. In addition, the patient is usually impatient with the tight, rigid, itchy dressing and the change gives him great relief. If there is a hematoma under the graft, that part of it is lost (Fig. 7). If an ordinary wound infection has resulted, the graft is lost. These should be avoidable circumstances, usually. Otherwise, at the first dressing, the graft should be a fairly uniform pink color. There may still be present a few rapidly fading "black and blue" spots. A full thickness graft viewed in 48 hours has a large portion of its area thus mottled. If, in spite of precautions to avoid it, there have been folds or wrinkles in the dressing, each of these may have caused a tiny superficial blister under the surface epithelium, and these may often be expected to cause superficial ulcerations. The graft is redressed, the same general technique being used as at the initial dressing. A daily

SUMMARY OF RESULTS IN 154 CONSECUTIVE GRAFTS

Small grafts—3 square inches or less in area

Total number 99
Number totally lost 1*

Medium sized grafts—approximately 3 to 5 square inches

Total number 43
Number totally lost ..... 1†

Large grafts‡—approximately 5 to 18 square inches

Case	Area grafted	Immediate result	Cause of loss	Final result
1	Cheek	Small area of ulceration at graft border	Hematoma	Slight permanent scarring. Considerable improvement over preoperative condition
2	Cheek, lower lip and chin	Area size of dime of full thickness loss. Several small areas superficial erosion	Hematoma. Intrinsic** infection	Some permanent scarring but very worthwhile result (see Fig. 6)
3	Neck	Area size of 5 cent piece superficial loss	Hematoma	Area of loss regrafted. Good final result (Fig. 13)
4	Neck	2 areas of 4 mm. diameter each superficial loss	Intrinsic infection	Slight permanent scarring. Good result
5	Neck	1 area size of dime superficial erosion	Intrinsic infection	Good result
6	Neck	No loss		Good result
7	Cheek	1 area 3 mm. diameter surface erosion	Intrinsic infection	Good result
8	Neck	2 areas 5 mm. diameter superficial erosion	Intrinsic infection	Good result
9	Neck	1 area 4 mm. diameter	Intrinsic infection	Graft good appearance. Borders formed keloid scars. Patient known to have tendency to keloid
10	Neck	2 areas 4 mm. diameter	Intrinsic infection	Graft good appearance. Borders formed keloid scars. Patient known to form keloids (Fig. 8)
11	Neck	2 small areas superficial erosion	Intrinsic infection	Graft good appearance and worthwhile result. One graft border developed heavier scar than usual
12	Forehead	No loss		Good result

*No other loss considered extensive enough to mar final appearance of graft seriously.

†In addition, 1 graft had 5 per cent of its area involved in an ulcer, and 4 grafts had small areas of ulceration at borders of graft which were of sufficient size to leave additional scar but still gave worthwhile improvement over original condition. A number of other grafts had small areas of superficial erosion which did not seriously mar final appearance of graft.

‡Of a total number of 12 large grafts, there were none completely lost. However, there was a definite increase in the incidence of superficial erosions, and for that reason a more detailed description is given.

**By intrinsic infection is meant a destructive infectious process arising from skin organisms which are within the skin itself and which become active during the period of low vitality before the skin graft has completely developed its circulation and resistance.

dressing is performed thereafter until the graft is out of danger. The reapplication of sea sponges, or equivalent pressure, is continued until the graft is 2 weeks old.

There is one important reason for the changing of dressings as early as the fifth or sixth day and the subsequent daily dressings. All skin contains bacteria, not normally virulent, which are in the pores and on its surface. A new graft, although its take is perfect, is struggling to maintain life and has none of the normal facilities for maintaining resistance. A full thickness graft must be 3 to 4 weeks old before it is strong enough to perpetuate new skin. During this period the low-grade bacteria present can initiate erosions of the graft. These most often begin in the tiny epithelial blisters previously mentioned, but may begin at any point. A carelessly applied dressing, even as late as the second week, can file on the graft and cause sufficient surface irritation to initiate such an ulcer. Early first dressings and daily change thereafter with removal of secretions, applications of sulfathiazole powder to any breaks, and the application of a mildly antiseptic ointment as before described tend to prevent and check these erosions, which, if unchecked, can destroy an entire graft or result in a rough surface after eventual healing (Figs. 6 and 7). The ordinary graft, with average success of take, should have a very small proportion of its surface area involved in any ulceration or infection.

Chances of success. It is impossible to express in percentages the chance of success of full thickness grafts, because this will vary so much with the individual case. The small grafts such as those applied to eyelids or small areas about the face can be undertaken with the same expectation of success that one would expect for the healing *per primam* of any type of clean operation in the same area. The number of failures will increase with the magnitude of the correction undertaken. Realization of the dangers and the avoidance of the pitfalls should reduce the chance of failure to such a point as to justify the attempt. If a full thickness graft does, unfortunately, fail to take, the area should be made clean as soon as possible by removal of the dead graft, and the frequent application of

constantly wet pressure dressings. Between the third and fourth postoperative week the wound should be regrafted with a thick split graft, the granulations but not the underlying plane of scar being excised. The graft so applied has a major chance of success (Fig. 13). The result will suffer chiefly in that some of the relaxation gained at the first operation has been reduced by the interval of healing. Even if two operations are necessary to obtain the result hoped for in one operation, often the patient has a better result more easily obtained than if the correction had been made by the use of flaps. The same is all the more true if one full thickness graft must be supplemented by others to gain full relaxation of a deformity such as a neck contraction, because then the total area of transplanted skin is greater than that easily available as flaps.

Subsequent course. On akinetic areas such as the cheek, it may take several months or a year for a graft to become soft and pliable and for its bordering scar to become minimal. If a graft border is subjected to irritating tension, it will keloid, as would any incisional scar. This means that its shape should be so planned as to avoid this and that the size must be such as to give relaxation. Sites of individual spots of full thickness or surface loss may in some instances produce unsightly scars but are usually so small as to heal without permanent blemish. In individuals known to produce keloids because of an inherent tendency and not because of mechanical factors of tension, infection, and irritation (Fig. 14), the graft borders are treated with radium 2 to 3 weeks after operation in the hope of minimizing this keloid.

PRINCIPLES WHICH SHOULD GOVERN THE LOCAL USE OF THE SULFONAMIDE DRUGS

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CLINICAL studies have demonstrated that the sulfonamide drugs applied locally are of value in the control of certain infections (1, 3–18, 24, 27, 32–35). In this paper are assembled certain facts about the action of these drugs on controlled quantitative studies by the method of human marrow culture (30). Deductions are made from these facts as to the method of application which should be most satisfactory, with the hope that these suggestions may serve as a guide to those who have clinical facilities for controlled comparison of the suggested method with other methods of use in the various infections.

METHOD

About 10 cubic centimeters of marrow or leucemic blood was introduced into a vaccine vial containing about 25 cubic centimeters of citrated balanced salt solution. After manipulations to remove the non-nucleated erythrocytes there was about 60 cubic centimeters of culture containing about 120,000,000 living, nucleated, human cells in a medium consisting of 35 per cent ascitic fluid and 65 per cent balanced salt solution, similar in composition to cerebrospinal fluid. This was thoroughly mixed and divided into two equal parts in vaccine vials, all manipulations being made with syringe and needle through vaccine caps covered with 70 per cent alcohol. One of these lots was then inoculated with a small number of organisms and the other with a large number. The vials were thoroughly mixed, and samples were removed for the initial pour plate colony count. Each of these vials was again mixed and an equal volume from each was transferred to each of five 30 cubic centimeter vaccine vials which contained respectively nothing, 1 gram of sulfanilamide per 100 cubic centimeters of final volume, 1 gram of sulfapyridine per 100 cubic centimeters of final volume, 1 gram of sulfadiazine per 100 cubic centimeters of final volume, and 1 gram of sulfathiazole per 100 cubic centimeters of final volume. The ten vials were then thoroughly mixed and placed in the incubator together. At intervals samples were withdrawn for pour plate colony counts, smears, and determinations of the drug concentration. Paraaminobenzoic acid in the proportion of 5 milligrams per 100 cubic centimeters was present in each pour plate, because this drug has been shown to inhibit the action of the sulfonamide compounds. Quantitative determinations of the drugs with the photoelectric colorimeter by the method of Bratton and Marshall were made on the supernatant fluid after centrifugation from each culture. The smears were stained with Wright's stain, and they were examined for the condition of the cells and for the number of organisms. The number of organisms compared well with the colony counts. The Staphylococcus aureus was used in two such experiments, and the Escherichia coli was used in one.

RESULTS

The results are shown in Tables I to III. Note from Tables I to III that none of these drugs is as effective against a large inoculation as against a small inoculation; that sulfanilamide in the concentration attained uniformly killed all living nucleated cells; that a considerable period of time, from 40 to 70 hours, is required for the action of the drugs when they are effective; that sulfathiazole and sulfanilamide are more effective in the concentrations attained than sulfadiazine and sulfapyridine; and that the solubilities of these

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TABLE I.—COMPARATIVE EFFECTIVENESS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF THE STAPHYLOCOCCUS AUREUS

Hours	0	16	19	40	43	70	Cells
Control	70* 18,000	0.0‡ 0.0‡	670,000,000* 1,150,000,000	0.0‡ 0.0‡	1,000,000,000*		
Sulfanilamide, 1 gm. per 100 c.c.	70 18,000	900.0‡ 840.0‡	80 1,640,000	1,036.0‡ 1,072.0‡	15 560,000	10* 2,100,000	Destroyed Destroyed
Sulfapyridine, 1 gm. per 100 c.c.	70 18,000	58.8‡ 59.5‡	150 43,000,000	55.8‡ 54.1‡	570 260,000,000	250,000 350,000,000	Intact Intact
Sulfadiazine, 1 gm. per 100 c.c.	70 18,000	92.8‡ 97.0‡	75 15,700,000	73.2‡ 75.4‡	160 92,000,000	5 460,000,000	Intact Intact
Sulfathiazole, 1 gm. per 100 c.c.	70 18,000	179.0‡ 170.0‡	110 600,000	180.5‡ 179.0‡	5 100,000	0 8,800,000	Intact Intact

*Colonies per c.c.
‡Milligrams of drug per 100 c.c. of supernatant fluid.

drugs in the marrow culture medium at 37 degrees C. is for sulfanilamide about 1,000 milligrams per 100 cubic centimeters, for sulfathiazole about 160 milligrams per 100 cubic centimeters, for sulfadiazine about 80 milligrams per 100 cubic centimeters, and for sulfapyridine about 55 milligrams per 100 cubic centimeters. Many other experiments by the marrow culture technique (19–31) have shown that in the concentration of 5 to 10 milligrams per 100 cubic centimeters, the concentration obtainable if the drugs are given by mouth, sulfathiazole is the most effective with sulfadiazine and sulfapyridine next in effectiveness and sulfanilamide the least effective against the Staphylococcus aureus, the beta hemolytic streptococcus of the Lancefield group A, the Streptococcus viridans, the Escherichia coli, the Salmonella schottmuelleri, the Eberthella typhosa, the Neisseria gonorrhoeae, and many different strains of different types of pneumococci. In marrow cultures, para-aminobenzoic acid, procaine hydrochloride and, presumably, related local anesthetics inhibit the action of the drugs of the sulfonamide group. Neoarsphenamine (23–26, 29) in a concentration of 75 to 200 gammas of arsenic per 100 cubic centimeters is more effective than any of the sulfonamide drugs against staphylococci and many strains of the Streptococcus viridans and beta hemolytic streptococcus.

OBJECTIVES OF LOCAL SULFONAMIDE THERAPY

The objectives of local therapy with the sulfonamide drugs are to prevent infection where infection is minimal or potentially present, to prevent the spread of infection already present, to eliminate infection already present, to avoid local damage to tissue cells, to avoid absorption of amounts of drug which might be toxic, to reduce the number of organisms present in the local area of infection before application of the drug to a number which can be controlled by the concentra-

TABLE II.—COMPARATIVE EFFECTS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF THE STAPHYLOCOCCUS AUREUS

Hours	0	18.5	22	40	45	64	69	Cells
Control	930* 82,000	0.0‡ 0.0‡	500,000,000* 900,000,000	0.0‡ 0.0‡	910,000,000*			
Sulfanilamide, 1 gm. per 100 c.c.	930 82,000	840.0‡ 928.0‡	30,000 420,000	1,128.0‡ 1,000.0‡	140,000 130,000	988.0‡ 1,046.0‡	2,000,000* 110,000,000	Destroyed Destroyed
Sulfapyridine, 1 gm. per 100 c.c.	930 82,000	18.3‡ 56.8‡	190,000 22,000,000	54.4‡ 55.8‡	430,000 160,000,000	56.6‡ 55.8‡	14,000,000 370,000,000	Intact Intact
Sulfadiazine, 1 gm. per 100 c.c.	930 82,000	27.3‡ 88.0‡	23,000 2,400,000	82.0‡ 83.0‡	16,000 13,600,000	82.6‡ 74.0‡	225,000 50,000,000	Intact Intact
Sulfathiazole, 1 gm. per 100 c.c.	930 82,000	48.1‡ 161.0‡	800 2,300,000	159.0‡ 150.9‡	35 240,000	142.0‡ 168.7‡	0 13,500,000	Intact Intact

*Colonies per c.c.
‡Milligrams of drug per 100 c.c. of supernatant fluid.

TABLE III.—COMPARATIVE EFFECTIVENESS OF MAXIMUM CONCENTRATIONS OF SULFONAMIDE DRUGS ON SMALL AND LARGE INOCULATIONS OF ESCHERICHIA COLI

Hours	0	17	20	40	44	70	Cells
Control	2,400* 650,000	0.0‡ 0.0‡	4,000 1,200,000,000	0.0‡ 0.0‡	1,000,000,000		
Sulfanilamide, 1 gm. per 100 c.c.	2,400 650,000	736.0‡ 752.0‡	360 1,600,000	1,000.0‡ 1,036.0‡	35 100,000	120 1,000,000,000	Destroyed Destroyed
Sulfapyridine, 1 gm. per 100 c.c.	2,400 650,000	56.6‡ 53.6‡	125 64,000,000	58.8‡ 58.8‡		160,000 1,000,000,000	Intact Intact
Sulfadiazine, 1 gm. per 100 c.c.	2,400 650,000	83.3‡ 83.3‡	45 28,000,000	81.0‡ 65.2‡	300 45,000,000	1,000,000 1,000,000,000	Intact Intact
Sulfathiazole, 1 gm. per 100 c.c.	2,400 650,000	162.0‡ 148.0‡	500 30,000,000	156.0‡ 148.0‡	350 75,000,000	2,500 1,000,000,000	Intact Intact

*Colonies per c.c.
‡Milligrams of drug per 100 c.c. of supernatant fluid.

tion of the drug which can be attained, to maintain an adequate concentration of the most effective and least toxic drug for an adequate period of time to eradicate completely the infection, to apply the drug in such a way that an adequate concentration is attained immediately and the drug is in contact with all the organisms, and to avoid introduction locally of any substance which would inhibit the action of the drug.

To attain these objectives in the light of the facts experimentally determined, the following general principles seem logical. There are two major indications for local use of these drugs. For prophylaxis of infection the sulfonamide drugs should be applied locally as soon as possible after any break in continuity of tissue in a potentially infected area after removal of any necrotic tissue and cleansing of the wound. For treatment of local collections of pus due to any organism against which these drugs are effective, local application should be made as soon as possible after an adequate blood level of the effective drug is attained, the pus and necrotic tissue have been removed by débridement and surgical drainage, and the number of organisms has been reduced by irrigation with a saturated solution of the drug in 0.85 per cent saline.

The drug of choice for local application will prove to be, except in rare instances, sulfathiazole. It is less toxic locally than sulfanilamide and more effective than sulfapyridine or sulfadiazine, and its lower solubility insures maintenance of an effective concentration locally for a longer period of time than would be true for an equal amount of sulfanilamide with less danger of producing an excessively high blood concentration. Sodium sulfathiazole should not be used locally, since it is so alkaline that it is likely to be irritating and produce tissue damage and since on neutralization by tissue fluids sulfathiazole is precipitated, so it has no advantages over application of the powdered sulfathiazole.

The administration of sulfathiazole or sulfadiazine by mouth or the intravenous administration of their sodium salts or of neoarsphenamine to attain an adequate blood level will eliminate the old contraindication to early operation, because this will take care of the small number of organisms which might be disseminated by early operation. By avoiding infiltration with local anesthesia, inhibiting drugs will not be introduced. Surgical drainage of any collection of pus with the removal of necrotic tissue and rinsing with saline saturated with sulfathiazole will eliminate temporarily the large number of organisms and will assure that there will be a saturated solution of the drug in contact with the organisms immediately. The application then of the finely powdered drug in quantities sufficient to maintain a concentration for at least 72 hours assures that the concentration will be maintained and that solution of the drug will take place rapidly to replace that which is absorbed. Closure without drainage insures that any air present will be promptly absorbed and that the fluid in which the drug is dissolved will then contact all surfaces. If drains are left in, air will be present with a resultant fluid level, and on the surface not

in contact with the drug the organism will multiply in large numbers and will then invade the areas in which there is an adequate drug concentration.

For oral use sulfathiazole should be the drug of choice, except when there is risk of meningitis or intolerance to sulfathiazole. In the latter case, sulfadiazine should be the drug of choice. The sodium salts of these drugs should be used intravenously for the first dose when immediate operation is indicated or when the patient cannot take oral medication. Neoarsphenamine should be used intravenously exactly as previously described (24, 25, 26, 29,) in serious staphylococcic or beta hemolytic streptococcic infections.

PREPARATIONS AND APPARATUS

It is convenient to have the following preparations and apparatus in stock; for oral use, 0.5 gram tablets of sulfathiazole and sulfadiazine; for intravenous use, sterile ampuls of sodium sulfathiazole solution and 0.15 gram ampuls of neoarsphenamine from which the solution may be freshly prepared each time an intravenous injection is to be given. For local use, the bulk finely powdered sulfathiazole is satisfactory for most purposes. Ordinarily it need not be sterilized further. For intracranial or intraspinal use, sterile sulfathiazole powder in ampuls is desirable. This may be prepared by placing 3.0 to 4.0 grams of the powder in pyrex test tubes or ampuls, drying it at about 85 degrees C. for 12 hours, sealing the ampuls while hot, and then autoclaving the ampuls for one half hour at 10 pounds pressure at 110 degrees. For application to open wounds and in the peritoneal cavity it is convenient to have 10 to 20 grams of sulfathiazole powder kept in sterile metal salt shakers. For application to the nose, throat, and through sinus windows or to large surfaces a powder blower filled with sulfathiazole powder is most convenient.

For application of the powder into tooth sockets, penetrating wounds or sinus tracts, various sizes of metal tubes fitted with plungers (18), are most satisfactory. To use these, the plunger is withdrawn and the tube is punched into the dry powder until the amount desired is in the tube. The tube is then inserted into the sinus pocket and the powder is forced out of the tube with the plunger as the tube is withdrawn. For application to superficial lesions when there is a tendency of the dressings to stick, an ointment made by incorporating 10 grams of the powder in 100 grams of aquafor is most satisfactory. For irrigation, a fresh saturated solution of sulfathiazole in sterile 0.85 per cent saline should be prepared before use by heating the saline to boiling and adding about 1.5 grams per liter of the powder and mixing until it has cooled to body temperature. For injection into the nasal accessory sinuses after irrigation with saline solution saturated with sulfathiazole, a freshly prepared 10 to 20 per cent suspension of the powder in one of the water soluble lubricating jellies, such as lubritine, K-Y jelly, or luzo, is best. The same suspension may be used in the eye, intraurethrally, or applied to the cervix inside a contraceptive diaphragm. It may be used instead of the ointment for skin lesions when the drying action of the powder is too great.

SPECIFIC RECOMMENDATIONS

Since attention to details and the correct sequence of steps are important, these specific recommendations are given as examples of the recommended therapy in each of a number of different types of conditions. From these examples, application to other conditions should be obvious.

Traumatic surgery. For fresh wounds within an hour of the time of injury, the wounds should be cleansed by the usual methods. The necrotic and devitalized tissue should be removed, and the wound irrigated with saline saturated with sulfathiazole. The sulfathiazole powder should be sprinkled or blown onto each surface just before coaptation. The wound is filled with the powder and sutured without drainage.

Penetrating wounds should be irrigated with saline saturated with sulfathiazole and packed loosely with sulfathiazole powder, tube and plunger of appropriate diameter being used.

If the wounds are more than an hour old or are grossly contaminated, the patients should be given sulfathiazole or sulfadiazine by mouth to obtain an adequate blood level

or sodium sulfathiazole should be given intravenously for the first dose if the wounds are of major importance. The wound should be opened, drained thoroughly, rinsed with saline saturated with sulfathiazole until the fluid returns clear, and then packed with sulfathiazole powder. The wound should be closed without drainage. Sulfathiazole should be continued by mouth until 3 days to a week after the temperature is normal, in doses sufficient to maintain a blood level of 5 to 8 milligrams per 100 cubic centimeters. Sulfadiazine should be substituted if there is toxicity from sulfathiazole or danger of meningitis. It is probably not safe to depend on sulfathiazole powder alone for prophylaxis against tetanus in penetrating wounds, so the usual tetanus prophylaxis should be used too.

Lesions of the skin and subcutaneous tissue. In epidermophytosis of the feet, or so called "athlete's foot," sulfathiazole powder used as a dusting powder from a salt shaker is very effective in clearing up secondary infections, although whether it will clear up the epidermophytosis itself is not yet established. In impetigo it should be used orally and by local application of the powder suspension in lubricating jelly or ointment after the crust is removed. Any ulcerating lesion, not due to syphilis or tuberculosis, may be benefited by the local application of the powder in lubricating jelly or ointment. This is particularly true in ulcerating secondarily infected cancer, which first should be cleansed and débrided, then rinsed with saline saturated with the drug followed by application of the powder or suspension in lubricating jelly. With furuncles or carbuncles, it is desirable to give the drug by mouth until an adequate blood level is obtained. Then the lesion should be opened as soon as free pus is evident. The pus should be rinsed out with a stream of saline saturated with the drug and the cavity filled with the powdered drug. Except when there is involvement of the upper lip or nasal mucosa or if there is already a blood stream infection, sulfathiazole by mouth need not be continued for more than 3 or 4 days after the furuncles are opened. If there is a furuncle in the upper lip or nasal mucosa or if the furunculosis is associated with a bacteriemia, one unit dose of 0.8 milligram per pound of body weight of neoarsphenamine is given intravenously every 4 hours for the first day and one unit dose every 8 hours thereafter for 9 days or until a week has elapsed from the last fever. Sulfadiazine is given by mouth in doses sufficient to maintain a blood level of 10 to 15 milligrams per 100 cubic centimeters. Both the first dose of sulfadiazine and neoarsphenamine should be given before the furuncle is opened and treated as here described.

Eye lesions. In gonorrheal ophthalmia, sulfathiazole is given by mouth to maintain a blood level of about 5 milligrams per 100 cubic centimeters and a continuous flow of saline saturated with sulfathiazole is kept dripping into the eye until the acute phase has passed and the edema has largely disappeared. Then the suspension of sulfathiazole in lubricating jelly should be applied every 2 hours while the patient is awake and every 4 hours during the night until cultures are negative. The suspension of sulfathiazole in lubricating jelly should be applied every 4 hours while patient is awake for another week, at which time it may be discontinued. For corneal ulcers and other bacterial infections of the eye, similar treatment may be given, the duration of the continuous drip of sulfathiazole in saline being modified from a few minutes to days according to the seriousness of the infection. For trachoma, a controlled comparison of the treatment with sulfathiazole in suspension in water soluble lubricating jellies should be made with the usual sulfanilamide therapy now employed.

Ear, nose, and throat lesions (27). For prophylaxis after operative procedures, sulfathiazole powder is blown from a powder blower on the site of operation immediately on completion. For beta hemolytic streptococcic pharyngitis, sulfathiazole powder is blown on to the inflamed areas at frequent intervals. For acute maxillary sinusitis, a blood level of 5 to 8 milligrams per 100 cubic centimeters is maintained by oral administration of sulfathiazole, the sinus is punctured, irrigated with saline saturated with the drug, and then filled with 20 per cent suspension of sulfathiazole in lubricating jelly. For chronic maxillary sinusitis, the same therapy should be used, but

the oral administration is not necessary. Several treatments at 3 day intervals may be necessary. For ethmoid, frontal or sphenoid sinusitis, the Proetz displacement technique is used to introduce the sulfathiazole suspension in lubricating jelly into the sinuses. For otitis media which has not responded to oral medication and lancing of the drum, the ear is wiped dry and a small amount of sulfathiazole powder is blown into the ear. After mastoid operations, sulfathiazole is continued by mouth for a week after the patient is afebrile, the pus is rinsed out with saline saturated with sulfathiazole after the operation, and the wound is packed with sulfathiazole powder, and sutured without drainage. The powder must be on the wound edges before coaptation.

Dentistry and oral surgery (18). After tooth extractions, the cavity should be filled with sulfathiazole powder by means of a tube and plunger, and the gums should be sutured over it.

Abdominal surgery. When operations on the large bowel are contemplated, sulfaguanidine by mouth in doses of 0.05 gram per kilogram divided into 6 doses per day for 3 days prior to operation should be given. Powdered sulfathiazole should be sprinkled on the operative site during and after operation. For general peritonitis, one dose of sodium sulfathiazole intravenously should be given just before operation, the abdominal cavity rinsed out with saline saturated with sulfathiazole, keeping suction going at the same time that the saline solution is being used for rinsing, so that no large volume of saline collects at one time. The irrigation should be continued until the return is clear. Then 10 to 30 grams of the powder are sprinkled from a salt shaker into the abdominal cavity. The same technique should be used for an abscess in the peritoneal cavity, except that manipulations should be confined to the infected area. Sulfathiazole powder should be sprinkled between the layers of the abdominal wall during closure and the incision closed without drainage. The blood levels must be checked, and enough sulfathiazole by mouth or sodium sulfathiazole intravenously should be given to maintain the blood level between 5 and 8 milligrams per 100 cubic centimeters for a week after the patient is afebrile.

Gynecology and obstetrics. Sulfathiazole powder should be blown or sprinkled between the cut surfaces in perineorrhaphy and episiotomy wounds. For puerperal and postabortal infections, adequate blood levels are attained by oral administration of sulfathiazole or intravenous administration of sodium sulfathiazole. Then very gently, by gravity, the uterine cavity is irrigated with saline saturated with sulfathiazole until the return flow is clear. Sulfathiazole powder is then introduced into the uterine cavity by means of the tube and plunger technique or with a powder insufflator.

Orthopedic surgery. In acute osteomyelitis with bacteriemia, neoarsphenamine as described here and sulfathiazole to maintain a blood level of 5 to 8 milligrams per 100 cubic centimeters are given. After the correct blood levels of these drugs are attained, the site of the osteomyelitis should be opened, rinsed with saline, and then filled with powdered sulfathiazole. In acute osteomyelitis without bacteriemia, neoarsphenamine need be continued for only 3 days and the sulfathiazole only for a week after the patient is afebrile. In chronic osteomyelitis the same therapy should be used, the neoarsphenamine and sulfathiazole being continued for 2 days after operation and the sulfathiazole for a week or more after operation. It is important that all dead tissue and the walls of infected sinus tracts be removed before the irrigation and packing with sulfathiazole powder.

SUMMARY

Investigations by the marrow culture technique show that in equal concentrations sulfathiazole is more effective than sulfapyridine, sulfadiazine, or sulfanilamide against any of the common pyogenic organisms, and that sulfanilamide is the least effective of these drugs. In concentrations attained in a saturated solution in a medium similar to tissue fluid, sulfathiazole and sulfanilamide are superior to sulfapyridine and sulfadiazine, and sulfathiazole is much less toxic to living human cells in this concentration than is sulfanilamide. None of these drugs is very effective against large numbers of organisms in any concentration attainable. Procaine hydro-

chloride and para-aminobenzoic acid inhibit the action of the sulfonamide drugs. Based on these observations certain principles seem logical. Local therapy for prophylaxis is indicated whenever there is a break in continuity of the skin or mucous membrane in a minimally infected or potentially infected area. Local therapy for the control of infection is indicated whenever there is a large number of pyogenic organisms present at one site. Of the drugs now available for local therapy, powdered sulfathiazole seems to be the drug of choice, since it is more effective than sulfapyridine or sulfadiazine and less toxic to cells in the concentrations attained than is sulfanilamide. Administration of sulfathiazole, neoarsphenamine, or sulfadiazine to maintain adequate blood levels before operation eliminates the old contraindication to early operation; namely, the dissemination of small numbers of organisms into the blood stream or into adjacent tissues. Surgical drainage and rinsing with a saturated solution of sulfathiazole in physiological saline temporarily reduces the number of organisms so that local application of sulfathiazole powder may prove effective. It insures that the full saturated concentration of sulfathiazole will be present at the moment of application. Enough of the powdered drug should be applied to maintain the saturated concentration for at least 72 hours. Local infiltration anesthesia should be avoided, since procaine hydrochloride and probably other local anesthetics inhibit the action of sulfathiazole. Preparations and apparatus needed for this therapy are described, and a number of illustrations of their use are given. For application to mucous membranes and for areas in which the powdered drug is too drying, the water soluble lubricating jellies make a satisfactory suspension medium, since the drug does not settle out, the mixture can be ejected through a fine needle, and it does not stick to dressings or impede drainage. Sodium sulfathiazole should not be used locally, since it has no advantages over sulfathiazole powder used as described and it is so alkaline that it is likely to produce extensive tissue damage.

REFERENCES

1. Bonnin, N. J., and Fenner, F. M. J. Australia, 1941, 1: 134–140.
2. Bratton, A. C., and Marshall, E. K., Jr. J. Biol. Chem., 1939, 128: 537–550.
3. Bullowa, J. G. M., Osgood, E. E., Bukantz, S. C., and Brownlee, Inez E. Am. J. M. Sc., 1940, 199: 364–380.
4. Campbell, W. C., and Smith, H. J. Am. M. Ass., 1941, 117: 672–675.
5. Childrey, J. H. Ann. Otol. Rhinol., 1940, 49: 709–712.
6. Colebrook, L., and Francis, A. E. Lancet, Lond., 1941, 1: 271–273.
7. Dees, J. G. Mississippi Doctor, 1940, 18: 215–217.
8. Hawking, F. Brit. M. J., 1941, 1: 263–268.
9. Herrell, W. E., and Brown, A. E. Proc. Mayo Clin., 1940, 15: 611–615.
10. Jensen, N. K., Johnsrud, L. W., and Nelson, M. C. Surgery, 1939, 6: 1–12.
11. Key, J. A. J. Am. M. Ass., 1941, 117: 409–412.
12. Key, J. A., and Burford, T. H. South. M. J., 1940, 33: 449–455.
13. Key, J. A., and Frankel, C. J. Ann. Surg., 1941, 113: 284–297.
14. King, A. C. Brit. M. J., 1941, 1: 231–233.
15. Livingston, G. S. J. Am. M. Ass., 1941, 117: 1081–1085.
16. Lovering, J., and Craig, W. McK. Proc. Mayo Clin., 1941, 16: 660–663.
17. McIntosh, J. Lancet, Lond., 1941, 1: 240–242.
18. Meacham, P. L., and Osgood, E. E. J. Am. Dent. Ass., 1941, 28: 1640–1644.
19. Osgood, E. E. J. Am. M. Ass., 1938, 110: 349–356.
20. Idem. Arch. Int. M., 1938, 62: 181–198.
21. Idem. J. Lab. Clin. M., 1939, 24: 954–962.
22. Idem. Marrow Cultures, in a Symposium on the Blood. Pp. 219–241. Madison, Wis.: The University of Wisconsin Press, 1939.
23. Idem. Proc. Soc. Exp. Biol., 1939, 42: 795–797.
24. Idem. J. Pediat., S. Louis, 1940, 17: 740–746.
25. Idem. Am. J. M. Sc., 1940, 200: 596–603.
26. Idem. J. Pediat., S. Louis, 1940, 17: 740–746.
27. Idem. Arch. Otolar., Chic., 1941, 33: 961–968.
28. Ibid. 1941, 33: 961.
29. Idem. Arch. Int. M., (in press).
30. Osgood, E. E., and Brownlee, Inez E. J. Am. M. Ass., 1937, 108: 1793–1796.
31. Osgood, E. E., Joski, Julia and Brownlee, Inez E. Surg. Gyn. Obst., 1940, 71: 445–450.
32. Rosenburg, S., and Wall, N. M. Surg. Gyn. Obst., 1941, 72: 568–578.
33. Spink, W. W. Sulfanilamide and Related Compounds in General Practice. P. 256. Chicago, Ill.: Year Book Publishers, 1941.
34. Spink, W. W., and Paine, J. R. Minnesota M., 1940 23: 615–619.
35. Veal, J. R., and Klepser, R. G. Med. Ann. District of Columbia, 1941, 10: 61.

STUDIES OF CEREBRAL OXYGEN CONSUMPTION FOLLOWING EXPERIMENTAL HEAD INJURY

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IT is generally assumed that many of the reversible signs and symptoms of brain injury, which follow trauma to the head, are a result of impaired blood flow to the brain or of oxygen deficiency in the blood supplying the brain or both. Treatment of head injury by intravenous injection of hypertonic fluids, by spinal drainage, or by oxygen therapy is believed to correct one or both of these factors. Impaired blood flow or stasis has never been demonstrated following head injury but is assumed to occur with a rise in intracranial pressure or with brain edema, in accordance with the Munro-Kellie concept of the cranium as a closed box. Such an assumption must be made with reservation if we consider certain limitations of concept.

We believe that stasis and decreased arterial oxygen are rather specious explanations for the pathological physiology of cerebral trauma. In early experiments we came to the conclusion that some more fundamental factor of disturbed physiology was responsible for the syndrome of head injury, and considered the possibility that the injured nerve cells might be unable to utilize oxygen normally in spite of an adequate oxygen supply. Some of the reasons for such a consideration are: (1) Symptoms of brain injury begin simultaneously with the trauma, before stasis or decreased blood oxygen can be thoroughly established. (2) The state of consciousness and other symptoms may show improvement while the stasis or oxygen content factors are developing. This is paradoxical if stasis and blood oxygen content are the sole pathological mechanisms involved. (3) We found in a number of experiments that immediately after head injury the oxygen content of venous blood from the brain was increased. This phenomenon cannot be explained on the basis of a reduced arterial oxygen or by stasis, in either of which event the reverse should be true. (4) While it is true that decreased oxygen saturation of arterial blood has been demonstrated following head injury,[1] this does not necessarily mean that cerebral oxygen consumption is decreased. The reduced arterial oxygen could be a manifestation of respiratory depression or an altered general metabolic state. Lennox and Gibbs[2] state that within certain limits the oxygen consumption of tissues is unaltered by changes in the oxygen tension of the blood. Furthermore, with a constant arterial oxygen during the course of an experiment, any change in the venous oxygen content of blood from a given tissue means either a change in the rate of blood flow through the tissue or an alteration in oxygen consumption by that tissue.

Because of the foregoing objections to the current concepts regarding the pathological physiology of head injury, this study of oxygen consumption by the brain in dogs before and after head injury was undertaken. Simple oxygen determinations of arterial and venous blood samples would not measure the net change in cerebral oxygen consumption, nor would measurement of cerebral blood flow alone answer the problem in the presence of so many other variables. Therefore, it was necessary to record the blood flow to the brain simultaneously with the removal of both arterial and venous blood samples, which were then analyzed for oxygen. These two factors, namely cerebral blood flow and arteriovenous oxygen difference (A-V difference) of brain blood, enabled us to calculate cerebral oxygen consumption with reasonable accuracy.[3]

From the Divisions of Surgery and Medicine, Northwestern University Medical School.

[1] Schnedorf, J. G., Munslow, R. A., Crawford, A. S., and McClure, R. D., Surg. Gyn. Obst., 1940, 70:628.

[2] Lennox, W. G., and Gibbs, E. L., J. Clin. Invest., 1932, 11:1155.

[3] We are aware of the anastomoses in the dog's carotid circulation which make it impossible to determine exactly how much of the internal carotid blood reaches the brain, but believe that with the technique used the values are approximately correct and valid for the purpose of these studies. Here we are concerned with *changes in cerebral oxygen consumption in the same animal* rather than with absolute values of oxygen consumption. Nevertheless our figures for cerebral oxygen consumption are of a magnitude similar to those recorded in the literature.

METHODS

A. Preparation of animals. Large dogs lightly anesthetized with nembutal were used in all experiments. The external carotid artery was ligated on the right side and a sterilized Rein thermostromuhr was applied to the common carotid artery just below the bifurcation. All branches of the carotid that were in the operative field other than the internal carotid were ligated. Care was taken not to disturb the carotid sinus nerves. On the left side the internal carotid was ligated. Thus most of the blood reaching the brain would pass through the thermostromuhr on the right carotid (Fig. 1). The vertebral vessels were not disturbed, and some blood would reach the brain through the vertebral arteries.

The internal jugular vein in the dog being of small size and unsuitable for repeated venipuncture, the external jugular vein was prepared for the easy withdrawal of blood samples. We previously determined by injection of the veins and cerebral sinuses that the external jugular in the dog drains a large part of the blood from the brain. Although the venous blood was not exclusively from the brain, we believe it is fair to assume that in this experiment changes in venous blood oxygen were more representative of changes in the brain than of possible changes in other structures of the head. The head was struck after closure of the wounds in the neck if the late effects of head injury were to be studied. If the immediate effects of injury were to be studied the animal was permitted to recover from the operative procedure before the head was injured.

Various methods of injuring the head were tried. The skulls of large dogs are extremely resistant to fracture, and severe trauma to the head is required to produce a gross brain lesion. The criterion of brain injury was a marked inhibition of respiration or apnea for a variable length of time. At the conclusion of the experiments the heads were examined, and many of the skulls were found to be fractured. The brains showed varying degrees of contusion and laceration.

B. Determination of oxygen consumption. Both femoral arteries were exposed and one was connected to a mercury manometer for recording blood pressure. The other artery was used for obtaining arterial blood samples. The thermostromuhr on the carotid artery was connected to a galvanometer. When the blood flow stabilized, simultaneous control samples of blood were withdrawn under mercury from the jugular vein and femoral artery. All blood samples were analyzed for oxygen in duplicate with the Van Slyke-Neill manometric apparatus. The blood flow was recorded continuously and further blood samples were taken for purpose of comparison at 15 to 80 minute intervals for a period of from 60 to 80 minutes.

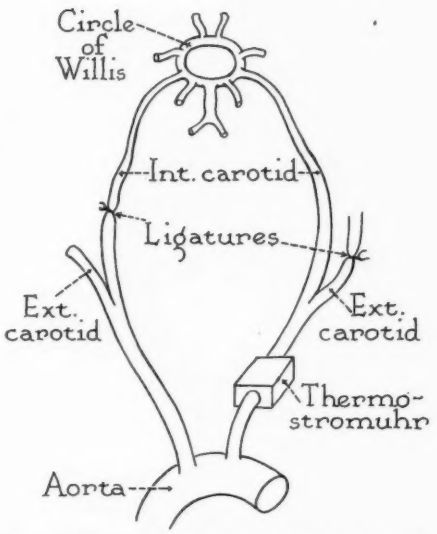
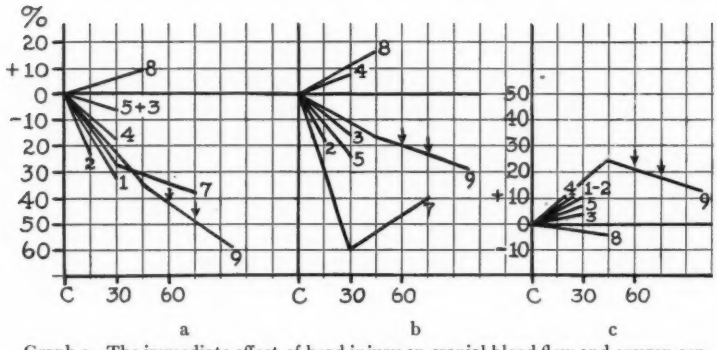


Fig. 1. Diagram of operative procedure for preparation of animals.

In some experiments two 20 cubic centimeter doses of 50 per cent glucose or sucrose solution were injected intravenously 15 minutes apart after control samples of blood had been obtained, and the experiments were then carried on in the same manner. In others, cisternal drainage was done and its effect on blood flow and A-V difference was observed. In two experiments 100 per cent oxygen was administered to animals suffering from 24 hour old head injuries. Control studies of the cerebral blood flow and of the A-V difference without any other treatment were carried out.



Graph 1. The immediate effect of head injury on cranial blood flow and oxygen consumption, and on the systolic blood pressure. The ordinates represent per cent change from the control value, 0. The abscissae represent time in minutes. Each line is a separate experiment. a, Shows change in cranial blood flow; b, change in oxygen consumption; c, change in systolic blood pressure.

DESCRIPTION OF RESULTS

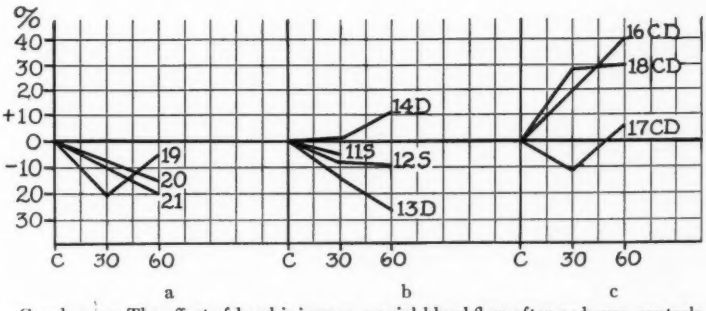
Four series of experiments measuring cranial blood flow and oxygen consumption were performed: (1) The immediate effect of head injury on the blood flow and oxygen consumption of the brain; (2) the later effect (after 24 hours); (3) the effect of administration of hypertonic sugar solutions 24 hours after injury; (4) the effect of draining cerebrospinal fluid from the cisterna magna 24 hours after injury. Observations were made of blood flow, arterial and venous oxygen content, arterial oxygen saturation, and arterial blood pressure. To facilitate a comparison of results all data are calculated in cubic centimeter per kilogram of dog per minute. In the graphs the variations in the values are presented in per cent of the initial control values of each experiment.

TABLE I.—SUMMARY OF DATA

Experiment	Number of dogs	Cranial blood flow		Cranial O_2 consumption	
		c.c./kg./min.	Per cent	c.c./kg./min.	Per cent
Control:	9	6.73		0.260	
After injury—20–40 min.	8	5.55	—17	0.193	—24
After injury—18–24 hrs.	10	5.44	—19	0.207	—21
Late injury—therapy: Hypertonic sugar:					
Control	4	5.65		0.225	
After drug:		5.40	—3	0.425	+98
Late injury—therapy: Cisternal drain					
Control	3	4.50		0.103	
After		5.03	+25	0.245	+138
Late injury—Time control:	3	6.10		0.290	
1 hr. later:		5.40	—11	0.310	+6

1. Immediately after head injury there is a steady and fairly consistent decline in cranial blood flow and cranial oxygen consumption (Graphs 1a and 1b, respectively). There is a fairly consistent increase of systolic blood pressure (Graph 1c). The average decrease in cranial blood flow in 8 experiments was 17 per cent, and the average decrease in cranial oxygen consumption was 24 per cent. The actual data are summarized in Table II. The individual values for cranial blood flow in this table vary from 4.1 to 10.0 cubic centimeters per kilogram per minute before injury and from 2.2 to 7.3 cubic centimeters per kilogram per minute after injury. The average values (Table I) are 6.73 and 5.55 cubic centimeters per kilogram per minute, respectively. The values for cranial oxygen consumption before injury were 0.10 to 0.50 cubic centimeters per kilogram per minute, while after injury they decreased to 0.06 to 0.31 cubic centimeters per kilogram per minute. The average values were 0.260 before and 0.193 cubic centimeters per kilogram per minute after injury.

2. Twenty-four hours after head injury the values for cranial blood flow and oxygen consumption are similar to those obtained immediately after injury. In a group of 10 dogs the



Graph 2. a, The effect of head injury on cranial blood flow after 24 hours, controls. b, The effect of hypertonic dextrose, *D*, and sucrose, *S*, on cranial blood flow 24 hours after injury. c, The effect of cisternal drainage on cranial blood flow 24 hours after injury.

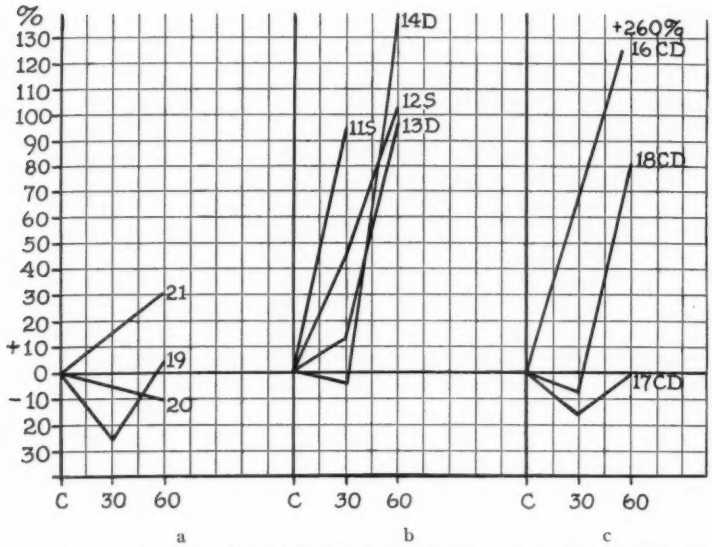
average change in cranial blood flow was minus 19 per cent of the control series (Table I). The cranial oxygen consumption was minus 21 per cent of the control value. The actual values of cranial blood flow for this group (Table II) ranged from 2.8 to 7.8 cubic centimeters per kilogram per minute, with an average of 5.44 cubic centimeters per kilogram per minute. For cranial oxygen consumption the range was 0.06 to 0.32 with an average value of 0.207 cubic centimeters per kilogram per minute.

3. Hypertonic sugar solutions were given intravenously to 4 of the dogs studied 24 hours after head injury. One-half to one hour after administration of these agents the cranial blood flow had decreased by 3 per cent, an insignificant amount, but the cranial oxygen consumption had increased 45, 90, 100, and 130 per cent, respectively. Changes in systolic blood pressure (Table III) were inconsequential. The solutions used, 50 per cent glucose and 50 per cent sucrose, produced similar effects (Graphs 2b and 3b). Table I shows that the average oxygen consumption after hypertonic sugar solutions was greater than the control values.

4. Drainage of cerebrospinal fluid from the cisterna magna was performed in 3 dogs 24 hours after head injury. The amount removed varied from 2 to 6 cubic centimeters. The effect of this procedure during an hour of observation is shown in Graphs 2c and 3c. An increase of cranial blood flow averaging 25 per cent was found. The increase in oxygen con-

TABLE II.—ACTUAL DATA

Experiment	Dog no.	Cranial blood flow c.c./kg./min.	Cranial O_2 consumption c.c./kg./min.
Before injury	2	7.3	0.28
After injury	2	5.8	0.22
Before injury	3	6.7	0.20
After injury	3	6.8	0.17
Before injury	4	5.6	0.28
After injury	4	5.0	0.31
Before injury	5	7.7	0.16
After injury	5	7.3	0.12
Before injury	6	8.3	
Before injury	7	5.3	0.26
After injury	7	5.8	0.29
Before injury	8	4.1	0.10
After injury	8	2.2	0.06
Before injury	9	10.0	0.29
After injury	9	4.2	0.18
Before injury	10	5.6	0.50
After injury	10	7.3	
24 hours after injury	11	2.8	0.07
After 50% sucrose	11	2.6	0.14
24 hours after injury	12	6.5	0.26
After 50% sucrose	12	6.1	0.37
24 hours after injury	13	6.2	0.32
After 50% dextrose	13	4.6	0.61
24 hours after injury	14	7.1	0.25
After 50% dextrose	14	7.9	0.58
24 hours after injury	16	6.3	0.13
After cistern drainage	16	8.8	0.51
24 hours after injury	17	5.0	0.12
After cistern drainage	17	5.3	0.12
24 hours after injury	18	2.2	0.06
After cistern drainage	18	2.8	0.11
Controls:			
24 hours after injury	19	7.8	0.66
One hour later	19	7.6	0.71
24 hours after injury	20	5.6	0.09
One hour later	20	4.8	0.09
24 hours after injury	21	4.9	0.11
One hour later	21	3.9	0.14



Graph 3. a, The effect of head injury on cranial oxygen consumption after 24 hours, controls. b, The effect of hypertonic sugar solutions on cranial oxygen consumption 24 hours after injury. c, The effect of cisternal drainage on cranial oxygen consumption 24 hours after injury.

sumption after cisternal drainage averaged 139 per cent. The effect of cisternal drainage on systolic blood pressure was to lower it (Table III).

TABLE III.—ACTION OF HYPERTONIC SUGAR SOLUTIONS AND CISTERNAL DRAINAGE ON THE SYSTOLIC BLOOD PRESSURE, 24 HOURS AFTER INJURY

Type of experiment	Dog no.	Systolic blood pressure		
		Control	30 min.	60 min.
Control	15	100	118	114
Control	19	105	105	94
Control	20	150		150
Control	21	135		140
Sucrose	11	128	140	
Sucrose	12	144	156	148
Dextrose	13	152	152	135
Dextrose	14	145	150	146
Cistern drainage	16	136	130	130
Cistern drainage	17	170	150	140
Cistern drainage	18	160	140	
Cistern drainage	Spec.	180	160	

Lest there be a question that the changes noted in the dogs studied 24 hours after injury could be due to nembutal anesthesia, three control animals were observed. These dogs had received head injuries 24 hours earlier and were studied for the same length of time as were the treated dogs. In these control animals (Graphs 2a and 3a), the blood flow declined 11 per cent and cranial oxygen consumption increased 6 per cent (Table I). The variations in oxygen consumption in the treated animals was vastly greater than this value. Little change was observed in the systolic blood pressure of the controls (Table III).

A reduction of oxygen saturation of arterial blood was regularly observed 24 hours after head injury. The values of oxygen saturation varied from 91 per cent to 73 per cent (Table IV) and are significantly lower than the values for oxygen saturation found in dogs lightly anesthetized with nembutal. This confirms the findings of Schnedorf and associates. In a few instances the total oxygen consumption of the animal per minute was studied. This value was not changed in animals suffering from immediate or late head injury. The adminis-

TABLE IV.—OXYGEN SATURATION OF ARTERIAL BLOOD 24 HOURS AFTER HEAD INJURY

Experiment	Oxygen content Volumes per cent	Oxygen capacity Volumes per cent	Saturation per cent
14	19.7	25.4	78
16	23.8	26.3	91
17	22.7	24.3	89
18	17.0	20.6	84
19	16.0	19.9	81
20	17.0	23.3	73
21	15.0	19.7	76

tration of 100 per cent oxygen to two animals during the course of the experiment caused no appreciable change in cerebral oxygen consumption compared to control values.

ANALYSIS OF STUDY

The pathological physiology of cerebral trauma cannot be entirely explained either by vascular stasis due to increased intracranial pressure or by decreased arterial oxygen saturation. The concept that symptoms of brain injury are due to stasis of cerebral flow resulting from increased intracranial pressure or increased brain bulk rests upon the so called Munro-Kellie doctrine. This implies that cerebral circulation depends on the hydrostatics of a closed box and on the systemic blood pressure. While this is essentially true, Wolff[1] and others have shown that the cerebral vessels are not passive channels for blood flow. Vasomotor phenomena among other things play a definite rôle in cerebral circulation. Because of the rapid decline in cerebral blood flow following head injury associated with a rise in blood pressure, we believe that vasomotor mechanisms are of much more importance in the early symptoms of head injury than brain edema or increased intracranial pressure. Furthermore, within certain limits there is no apparent quantitative relationship between the amount of blood flowing to the brain and the severity of symptoms of brain injury. In regard to the rôle of available oxygen, we were unable to demonstrate that ordinary changes in arterial oxygen saturation affect brain oxygen consumption. We are forced to the conclusion, therefore, that symptoms of brain injury are not solely a result of circulatory changes, but that the nerve cells themselves are so affected by injury that they function inadequately. This is borne out by the finding of a decreased cerebral oxygen consumption immediately following injury.

[1] Wolff, H. G. Physiol. Rev., 1936, 16: 545.

CONCLUSIONS

1. Within an hour after trauma sufficient to cause contusion of the brain in dogs, there was an average decrease of 24 per cent in cerebral oxygen consumption, and of 17 per cent in cerebral blood flow. The following day there was but little change in these values.

2. The administration of 50 per cent glucose or sucrose to dogs with a 24 hour old head injury was followed within an hour by a striking increase in brain oxygen consumption but no significant change was noted in cranial blood flow.

3. Drainage of cerebrospinal fluid in dogs with 24 hour old head injuries was followed by an even greater increase in brain oxygen consumption and by a 25 per cent increase in cranial blood flow.

4. The administration of 100 per cent oxygen to 2 animals during the course of the experiment caused no appreciable change in cerebral oxygen consumption, compared to control values.

5. These experiments indicate that the impaired cerebral blood flow following head injury is affected relatively little by therapy, whereas cerebral oxygen consumption is strikingly increased. The oxygen consumption of the brain is not dependent on blood flow alone or on arterial oxygen alone. We believe that the metabolism of the nerve tissues and their ability to use oxygen is directly affected by head injury. Such a mechanism could explain the phenomenon of concussion.

6. Since hypertonic solutions and spinal fluid drainage increase brain oxygen consumption, there is a rational basis for their use for this purpose.

LOCAL SULFANILAMIDE IN COMPOUND FRACTURES

An Experimental and Clinical Evaluation

N. K. JENSEN, M D., and M. C. NELSON, M.D., Minneapolis, Minnesota

EARLY in 1938 we initiated an experimental and clinical study of the feasibility of implanting sulfanilamide powder in compound fractures. Prior to this, Brown in England and Jaeger, Tiling, and Merz in Germany had reported the local use of prontosil soluble (neoprontosil) in the treatment of a few cases of established infections, but no one had reported either an experimental or clinical study of the prophylactic value of sulfanilamide in the treatment of contaminated wounds.

A preliminary report on this study was submitted for publication in February of 1939. The present paper, for the sake of completeness, includes most of the experimental and clinical data from this earlier publication. In addition, we are reporting all of the compound fractures treated up to December 1 of 1941.

From December of 1937 to July of 1939 the treatment of these fractures was carried out by Dr. Johnsrud or one of us. Since then the actual treatment has been by Drs. Freedman, Welte, Moos or Farkas, fracture residents for the successive semiannual periods. Occasional patients have also been treated by members of the visiting staff. This has unavoidably resulted in some variation in treatment, particularly as each of these men started their fracture residencies as relatively inexperienced surgeons. Every effort was made by these men, however, to follow the basic fundamentals of the program which we had initiated. Furthermore, from the beginning this work has been carried out under the supervision of Dr. A. A. Zierold, professor of surgery at the University of Minnesota, and chief of the surgical service at the Minneapolis General Hospital. This constant change in operative personnel adequately eliminates the personal factor from the clinical studies. However, a skilled surgeon personally handling this number of consecutive cases would have avoided some of the recurrent errors which were made in this series.

From the Minneapolis General Hospital and the Department of Surgery of the University of Minnesota.

Dr. Jensen is now on active duty as a Major in the Medical Corps of the U.S. Army.

EXPERIMENTAL STUDIES

In our earlier report we showed that sulfanilamide powder buried in a wound gradually finds its way into the general circulation, reaching a maximum level in the blood at the end of about 18 hours and finally disappearing in about 60 hours. Marshall's studies have shown that after a single large dose by mouth practically all the drug is eliminated in 24 hours. This would indicate that absorption continues from a wound for over 30 hours. During this time actual measurements (11) in man have shown that the serum, hematoma, and local tissues of the wound are saturated with sulfanilamide at approximately 0.8 per cent concentration, the solubility of this compound at body temperature.

Hawking has subsequently studied the absorption of solid sulfanilamide from wounds of guinea pigs and rabbits and found that high local concentrations persist for 24 hours. However, it is probable that the drug is absorbed faster from the wounds of small animals due to the fact that their metabolic rate is higher.

These observations indicate that locally implanted sulfanilamide gives a concentration in the area of contamination 80 times that obtainable by systemic administration. Since the bacteriostatic and bactericidal power of sulfanilamide is a function of its concentration, other things being equal, it is logical to assume that local implantation will be more effective in the prevention of infection of contaminated wounds than will systemic administration.

TABLE I.—COMPOUND FRACTURES OF RIB—WOUNDS CONTAMINATED WITH FRESHLY ISOLATED (24 HOURS) CULTURE OF STAPHYLOCOCCUS AUREUS HEMOLYTICUS; 0.5 GRAM SULFANILAMIDE POWDER IMPLANTED

Local sulfanilamide		Systemic sulfanilamide		Control	
No.*	Result	No.	Result	No.	Result
17	Infected 8th day#	22	Died 4th day (autopsy§)	1	Wound draining 4th day
18	Infected 8th day†	23	Died 8th day (autopsy§)	2	Wound draining 6th day
16	Sacrificed 3rd day‡	27	Wound draining 4th day	3	Wound draining 7th day
7	Healed *per primam*	13	Wound draining 4th day	11	Wound draining 8th day
6	Healed *per primam*	19	Wound draining 6th day	9	Sacrificed 3rd day¶
5	Healed *per primam*	25	Wound draining 6th day	8	Healed *per primam*
15	Healed *per primam*	26	Wound draining 6th day	10	Healed *per primam*
14	Healed *per primam*	20	Wound draining 6th day		
12	Healed *per primam*	21	Healed *per primam*		
4	Healed *per primam*	24	Healed *per primam*		
20% Infection No deaths		80% Infection 20% Mortality		71.4% Infection No deaths	

*No. refers to identification number of animals.
#Wound left gaping allowing drug to drain away with serum; result, infection.
†Subjected to 3 cardiac punctures in 3 days, removing a total of 10 c.c.
§Autopsy of pigs with systemic sulfanilamide showed acute pleurisy, severe wound infection and wound and heart blood cultures showed Staphylococcus aureus hemolyticus.
‡Autopsy of pig sacrificed after 3 days with local sulfanilamide revealed clean healing wound and no evidence of metastatic spread. Culture from wound revealed Staphylococcus aureus hemolyticus; from heart's blood, negative.
¶Autopsy of control animals at 3 days revealed severe wound infection, acute pleurisy, bronchopneumonia. Culture of wound and heart's blood revealed Staphylococcus aureus hemolyticus.

The following experiments were designed to test the validity of this assumption and define the factors present in traumatic wounds which might lead to infection even in the presence of sulfanilamide. The guinea pigs selected for these studies were of uniform size and age and all were free from previous pyogenic infection. A standard wound was produced under ether anesthesia by incising the pectoral muscles of the guinea pigs and fracturing a rib on one side. This fracture was adopted because here the motion of the fragments would be uniform from animal to animal, being determined by their respiration. In those instances in which the pleura was opened the animals were discarded. Closure was by fine silk or cotton suture to the skin only. When sulfanilamide powder was inserted, it was spread uniformly throughout the wound prior to closure. The culture used in experiment I was a Staphylococcus aureus hemolyticus freshly isolated from the blood of a youth dying of Staphylococcal septicemia. In the subsequent experiments we used a lyophilized Staphylococcus aureus hemolyticus, coagulase positive, supplied us by Dr. George A. Hunt. These organisms were prepared for inoculation by culturing 24 hours in peptone broth; then freed of the broth by repeated centrifugation and resuspension in sterile normal saline. The number of the organisms was then calculated by centrifugation of an aliquot in a Hopkins tube which had been calibrated by plate counts for this particular organism.

Thus by obtaining a strain of Staphylococcus aureus of assured standard virulence and by using this organism in known number as an inoculum in standard wounds in uniform nonimmune animals, the factors resulting in infection could be assayed. The questions to be answered were: (1) Is local sulfanilamide more effective prophylactically than systemically administered sulfanilamide? (2) How does the number of organisms originally inoculated in the wound influence the outcome? (3) What is the effect of foreign particulate matter in the wound? (4) What is the effect of macerated dying tissue in the wound?

DISCUSSION OF EXPERIMENTAL STUDIES

Experiment 1. The comparison between local and systemically administered sulfanilamide (Table I) shows that local sulfanilamide protects against staphylococcal infection in a

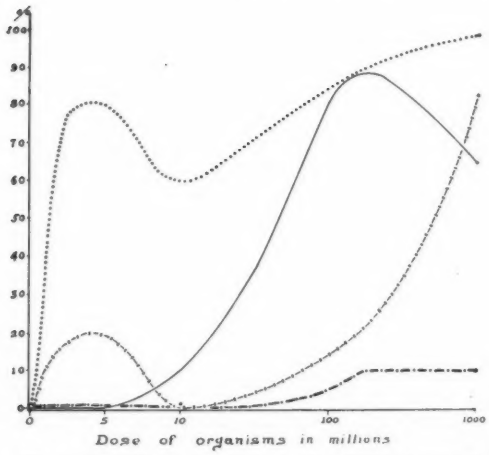


Fig. 1. Graphic expression of results in experiment II. ...., controls; —— local sulfanilamide infection; —•—•— controls; —|—|—|—|—, local sulfanilamide, deaths.

high proportion of animals—80 per cent—whereas the same amount systemically administered fails almost completely—80 per cent infected, 20 per cent died. Stimulated by the preliminary report of our work (11), Nitti in France, carried out similar experiments in rabbits using beta hemolytic streptococci. His studies likewise revealed that local sulfanilamide implanted at the time of contamination of the wound was very effective. More recently, Hawking found that local sulfathiazole protected 58 per cent of animals inoculated with Clostridium welchii and Clostridium septique, whereas systemic administration of the same amount of drug even 2 hours previously saved only 23 per cent of the animals.

Experiment 2. The most obvious factor conditioning the development of infection in any wound is the number and virulence of the organisms contaminating the wound. The studies reported in Table II and Figure I show that sulfanilamide locally implanted does not alter this consideration. The presence of local sulfanilamide will allow a wound to heal *per primam* with a much larger initial contamination than is otherwise possible. However, if the dose of organisms be great, sulfanilamide will not prevent the development of local suppuration. It appears, however, that even

TABLE II.—PROGRESSIVE FAILURE OF LOCAL SULFANILAMIDE AS SIZE OF DOSE OF CONTAMINATING ORGANISMS IS INCREASED

Dose of organisms	No.* of animals	Control		0.25 gm. sulfanilamide	
In millions	Total 72	Infections	Deaths†	Infections	Deaths†
2.5	5	4 (80%)	1 (20%)	None	None
5	5	4 (80%)	1 (20%)	None	None
10	10	6 (60%)	None	1 (10%)	None
200	10	9 (90%)	2 (20%)	9 (90%)	1 (10%)
1000	6	6 (100%)	5 (83.3%)	4 (66%)	1 (10%)

Hunt culture used (staphylococcus aureus hemolyticus). Standard compound fracture of rib produced as described.

*No. of animals refers to the number used in each experiment as controls and as treated animals. Total number is necessarily double this.

†All animals that died were examined postmortem. Invariably with this strain of organisms metastatic abscesses in liver and kidneys were found in addition to severe wound infections and frequently acute pleurisy with bronchopneumonia. Cultures of these abscesses and heart's blood revealed Staphylococcus aureus hemolyticus.

with an overwhelming dose, local sulfanilamide will protect many of the animals against fatal sepsis as the mortality rate is much less in the treated animals than in the controls (Fig. 1).

In vitro studies show this same phenomenon. Many workers have observed with all the sulfonamides that if the inoculum be too great no bacteriostasis is demonstrable. The clinical application of this fact is obvious. Débridement of contaminated wounds must be carried out meticulously enough so as to reduce materially the number of contaminating organisms.

Experiment 3. King and Henschel's studies beautifully demonstrate *in vitro* the inhibition of sulfanilamide by autolyzing tissue. These workers found that a tiny fragment of dying muscle, liver, or brain in a Maximow tissue culture containing sulfanilamide allowed colonies to develop in its immediate vicinity, whereas bacteriostasis was excellent in all other parts of the culture. Figures 2, 3, and 4 show this very well.

Table III shows the effect of a fragment of macerated muscle in wounds. It is evident that local sulfanilamide is not of much value in the presence of dying tissue. Clinically this means that a débridement must be thorough enough to excise all macerated and devitalized tissue if local implantation of sulfanilamide is to be of any benefit. Furthermore, whatever

TABLE III.—FAILURE OF LOCALLY IMPLANTED SULFANILAMIDE IN THE PRESENCE OF MACERATED MUSCLE

No. of animals	Sulfanilamide	Macerated muscle	Infection	Death
8	0.25 gm.	No	None	None
8	0.25 gm.	Yes	8 (100%)	1* (12.5%) (5 days)
2	None	No	2 (100%)	None
2	None	Yes	2 (100%)	1* (50%) (7 days)

Standard compound fracture of rib produced, contaminated with culture of staphylococcus aureus hemolyticus (coagulase positive) and streptococcus hemolyticus freshly isolated from wound of guinea pig dying of this infection; macerated muscle fragment (3 by 3 by 2 mm.) left in wounds as indicated.

*Autopsy of the two guinea pigs that died showed multiple metasti abscesses in liver and spleen.

closure is attempted must avoid strangulation of tissue, and buried *absorbable* suture material should be avoided. Immobilization must be complete to prevent further damage to soft parts which might be caused by motion of the bony fragments.

Experiment 4. Local sulfanilamide appears to be of limited value in the presence of foreign material in the wound.[1] In the experiments reported here, Table IV, the animals with charcoal and sulfanilamide in their wounds did a little better than those with charcoal and no sulfanilamide. The animals without either did much better, while those with no foreign material and sulfanilamide healed *per primam*. Nitti's studies show that implantation of a piece of fabric saturated with a culture of virulent hemolytic streptococci quickly kills an unprotected rabbit. Implantation of sulfanilamide at the same time appears to protect the animals against fatal sepsis for a time. If the wound is reopened in 48 hours, the fabric removed, débridement accomplished, and sulfanilamide again implanted, most of the animals live. When death occurs, it is delayed for an interval of 8 or 10 days. The experiments of Legroux and Hawking also show this same effect of locally implanted sulfanilamide.

Here again the clinical implication is that débridement must be thorough enough to remove all foreign material and soiled tissue if

[1] Vitallium seems to be an exception—see Clinical Discussion, Fig. 7.

TABLE IV.—EFFECT OF FOREIGN MATERIAL IN CONTAMINATED WOUNDS TREATED WITH LOCAL SULFANILAMIDE IMPLANTATION

No. of animals	Sulfanilamide	Charcoal	Infection	Death
3	0.25 gm.	0	None	None
3	0	0	3 (100%)	None
3	0.25 gm.	0.050 gm.	3 (100%)	2 (66.6%)
3	0	0.050 gm.	3 (100%)	3 (100%)

Standard compound fracture as previously described, contaminated with 5 million organisms (Hunt strain of staphylococcus aureus). Guinea pigs used. Charcoal sterilized by autoclave (250° C. for 20 minutes).

the implantation of sulfanilamide is to be of great benefit in promoting healing without suppuration. However, it may be that in the presence of foreign material retained unduly long, as in Nitti's experiments, local sulfanilamide will prevent the development of fatal sepsis, and delayed débridement can be carried out with reimplantation of the drug at this time.

Experiment 5. For the studies on gas gangrene a mixed culture was selected because the cases seen at the Minneapolis General Hospital have almost invariably resulted from such a mixture of one or more of the Clostridia with hemolytic streptococci. Clinically, it has been our observation that this type of gas infection does not necessarily depend for its development on devitalized muscle or imbedded foreign material. The invasive virulent streptococci produce all the tissue devitalization required by the anaerobes. Débridement alone will not obviate these infections as we saw them prior to our use of sulfanilamide following careful meticulous débridement of compound fractures, following elective amputations where the only damage to muscle was that which was produced by a sharp amputation knife, and even following guillotine amputations.

Table V shows that local sulfanilamide will prevent infection in wounds inoculated with a lethal mixture of streptococci, staphylococci, and Clostridium welchii. The recent study of Hawking in England throws additional light on this subject. He found that sulfanilamide used locally protected 53 per cent of his animals against a fatal dose of Clostridium

TABLE V.—PROPHYLAXIS OF GAS GANGRENE INFECTION BY LOCAL IMPLANTATION OF SULFANILAMIDE

No therapy		Local sulfanilamide 0.25 gm.	
Animal	Result	Animal	Result
1	Sacrificed 7th day*	1	Healed *per primam*
2	Died 8th day	2	Pyogenic wound infection†
3	Severe gas infection—recovered	3	Healed *per primam*
4	Died 2nd day	4	Healed *per primam*
5	Died 6th day	5	Sacrificed 7th day‡
Gas gangrene 100% Mortality 80%		No gas gangrene No deaths	

Wounds produced by clean incision through pectoral muscles to ribs; no ribs cut; no effort made to macerate muscle; wounds inoculated with 3 loops of material from gangrenous wound of guinea pig dying 72 hours after inoculation with mixture of Clostridium welchii, Staphylococcus aureus hemolyticus, coagulase positive, and beta Streptococcus hemolyticus. Culture of this material as used for inoculation in this experiment revealed these same organisms. This culture was originally recovered from a clinical case of gas gangrene following socalled "minimal" compound fracture of forearm (not treated by us).

*Sacrificed just before death for blood culture. This was positive for all three organisms inoculated, as was wound culture. Autopsy showed extensive gangrenous destruction with much gas of almost all the muscles of right side of chest and upper abdomen.

†Few drops of pus obtained from wound on 6th day. Culture Staphylococcus aureus hemolyticus, coagulase positive. Wound healed without breaking down by 10 days.

‡Sacrificed to compare with infected animals sacrificed on same day (*). Culture of heart's blood was sterile; of wound revealed Staphylococcus aureus. Autopsy showed no abnormalities except a little edema with some pus (2–3 drops) in depth of wound. Skin had healed *per primam* at this time.

welchii in the presence of macerated muscle and foreign material.[1] Legroux somewhat earlier studied the effect of local sulfanilamide. He found that wounds infected by insertion of a piece of cloth soaked in a culture of Clostridium welchii or Clostridium histolyticum caused death in control animals in 2 to 3 days, whereas animals which received local sulfanilamide died after 4 to 7 days, but if the wound were reopened, the cloth removed and new sulfanilamide added, they survived. Delay of the treatment for more than 1 hour after insertion of the culture, or the administration of the drug only by mouth, resulted in death of the animals.

Hawking also studied Clostridium septique and Clostridium oedematiens infections. He found local sulfanilamide delayed the death of animals infected with Clostridium septique and protected 28 per cent of the animals against Clostridium oedematiens.[2] Sulfathiazole, however, protected 67 per cent of the animals against Clostridium septique but only 33 per cent against Clostridium oedematiens. Sulfapyridine was inferior to both sulfanilamide and sulfathiazole. Serum (antitoxin), both specific monovalent and polyvalent, was found ineffective against some of the strains of Clostridium welchii which were studied, against all of the strains of Clostridium septique, but worked very well against Clostridium oedematiens.

Hawking suggests that sulfathiazole or a mixture of one part sulfathiazole and two parts sulfanilamide be used locally in conjunction with serum to cover the Clostridium oedematiens infections. This may come to be the best practice. However, it should be pointed out that in the 212 compound fractures reported in this paper not a single case of gas gangrene has occurred in a fracture when adequate débridement was performed and local sulfanilamide implanted.[3] Polyvalent serum was also given prophylactically to all these patients.

EFFECT OF TEMPERATURE

In vitro studies by many investigators of the bacteriostatic power of sulfanilamide against a variety of organisms have revealed that the activity of the drug is greatly enhanced by temperatures of 37 degrees C. and above. White, studying the streptococcidal[4] activity of this compound, reports that at 30 degrees C. concentrations of less than 1000 milligrams per cent are inactive, at 36 degrees C. concentrations of less than 100 milligrams per cent are inactive, while at 39 degrees C. concentrations of less than 10 milligrams per cent are bactericidal. He points out that sulfanilamide is 100 times as active at 39 degrees C. as at 37 degrees C. Spink found sulfanilamide to be much more active at 40 degrees C. than at 37 degrees C. against staphylococci. Neter reports the same obser-

[1] Note that both Hawking and Legroux are studying death rates from infection, not incidence of infection. All their animals developed some infection and in that sense are not comparable to our studies.

[2] 11 per cent of the controls of this series survived.

[3] We have had 2 cases of gas gangrene, demanding amputation, after local implantation of sulfanilamide. In both instances examination of the wounds after amputation revealed imbedded gross foreign material.

[4] Hemolytic streptococci, Lancefield, A. Type I, Griffith.

vations with both hemolytic and nonhemolytic enterococci.

These studies suggest that in the prophylactic use of sulfanilamide, the temperature of the wound should be kept at 37 degrees C. or above. It may prove worthwhile to use diathermy to raise the local temperature of an extremity during the critical first 24 to 36 hours. In our clinical studies we have unconsciously taken some advantage of this phenomenon.

SUMMARY

In summary our experimental investigations and those reported by others suggest:

1. Sulfanilamide is more effective when implanted locally than when systemically administered in the prophylaxis of wound infection.

2. Local sulfanilamide will not prevent infections in the presence of massive doses of contaminating organisms, although it does appear to lessen the severity of these infections.

3. Devitalized tissue will inhibit the activity of locally implanted sulfanilamide.

4. Foreign particulate matter will protect the contaminating organisms against sulfanilamide.

5. Sulfanilamide locally administered is more effective against Clostridium welchii and Clostridium histolyticum infections than systemically administered drug. It is of little value against Clostridium septique or Clostridium oedematiens with either route of administration. (a) In wounds carefully excised, gas bacillus infections are rare unless invasion and devitalization of the tissue by a virulent aerobic organism occurs (e.g. Streptococcus hemolyticus). Local sulfanilamide will protect against this type of infection and consequently greatly reduce the incidence of anaerobic infections. (b) Sulfathiazole locally implanted is effective against Clostridium septique (Hawking). (c) Polyvalent serum (antitoxin) seems to be the most effective agent for Clostridium oedematiens (Hawking). (d) Delay of even 1 hour in local implantation of the drug in gas bacilli contaminated wounds materially reduces the effectiveness of sulfonamides (Legroux).

6. The antibacterial action of sulfanilamide is directly proportional to the temperature. It is suggested that means be used to keep the temperature of a wound at 37 degrees C. or above during the first 24 to 36 hours.

CONCLUSION

Reduction of the dose of contaminating organisms and excision of all devitalized tissue by careful meticulous débridement of compound fractures followed by complete immobilization of the fragments and appropriate steps to maintain the temperature of the wound at 37 degrees C. or above will fulfill the requirements for effective local antibacterial action of solid sulfanilamide implanted in these wounds.

CLINICAL STUDIES

PRELIMINARY CONSIDERATIONS

Any substance that is to be implanted in wounds must fulfill two primary requisites: it must be nontoxic to the local tissues and absorption of the substance must not produce toxicity in the patient.

Our studies (11) of the absorption and excretion of sulfanilamide have shown that 5 to 20 grams can safely be placed in a wound without fear of excessive systemic concentration of the drug.[1] We have found that the blood level will be at its maximum in 18 to 20 hours and in an average size adult with normal renal function the blood level will be in milligrams per cent about the same as the number of grams of drug implanted if the wound be closed primarily (e.g. 10 to 12 milligrams per cent for 10 grams implanted in a compounded tibia). If the wound be left open and covered with vaseline gauze, the level in the blood will be much less; consequently, larger doses can advantageously be used.

In the 212 cases which are reported here we have not seen a single instance of toxicity from the use of the drug other than the usual cyanosis. We have also used it in many other wounds as will be mentioned and have observed no toxicity.

[1] This statement applies only to wounds, not to serous cavities. The drug is probably much more rapidly absorbed from the pleural and peritoneal surfaces and here 5 grams should be the maximum (Richard Varco, personal communication).

The second consideration is the effect of the compound on local tissues and healing. Key and Burford have reported an excellent study of this phase of the problem, and their conclusions that no significant delay in healing occurs with sulfanilamide is well supported by our clinical experience with the use of the compound in a wide variety of wounds which were cared for at the Minneapolis General Hospital.

For more than 3 years we have implanted sulfanilamide powder in all tendon lacerations which were primarily sutured and in all herniorrhaphies in which fascia transplants were used. With both "split thickness" and "full thickness" skin grafts, it has been our custom to dust the graft bed with a thin layer of sulfanilamide powder before suturing the grafts in place. We then again apply a thin layer of sulfanilamide powder over which a xeroform ointment dressing with sea sponge pressure is applied. The results have been excellent. Tendons heal without infection and failure of union has been infrequent. Our use of large fascial grafts has increased considerably since we found that with sulfanilamide locally implanted the chance of postoperative infection was greatly reduced and firm healing progressed rapidly. Skin grafts which have been dusted with sulfanilamide take as rapidly as do those which have not been so treated, and the occasional loss due to infection has been avoided.

A more critical study of the effect of local sulfonamides on tissue has been made by Russell and Falconer in England. These workers injected suspensions of solid sulfanilamide, soluseptasine, and sulfapyridine into the brain of rabbits. Microscopical preparations made at suitable intervals were then studied. No cellular reaction was found in the case of sulfanilamide or soluseptasine. Foreign body reaction occurred about the sulfapyridine crystals which were very slowly absorbed. Hurteau of Canada has studied the effect of implantation of sulfanilamide, sulfapyridine, and sulfathiazole into operative incisions in cats' brains. In like manner it was impossible for him to demonstrate any deleterious effects resulting from the use of sulfanilamide.

TREATMENT

As sulfanilamide is not a panacea, it is essential that the conditions under which it has been used in this study be outlined completely.

The compound fractures admitted to the Minneapolis General Hospital have usually resulted from automobile accidents. Our patients are drawn from the very poorest of the city—from the unfortunate, undernourished and unwashed side of life. All this results in terrifically contaminated fractures with a great deal of soft tissue damage. Many patients sustaining compound fractures exhibit shock on admission to the hospital, and all show evidence of impending shock. Successful treatment of the fracture demands prompt treatment of the shock, and we have found nothing better than control of pain and transfusion of plasma or whole blood if necessary.

X-ray pictures are obtained in seriously injured patients only after shock treatment has been instituted and usually after the patient has been transported to the operating suite. We are of the opinion that the time consumed for these films is well spent, as they often bring a much better realization of the extent of the injury than does observation alone.

We have avoided local infiltration anesthesia because of the danger of carrying infection into the deeper tissues and because the discovery by Woods that procaine is a very potent sulfonamide inhibitor *in vitro* suggests that the *in vivo* action may be similar. In most instances, regional block such as brachial plexus block for the upper extremity and spinal anesthesia for the lower have been used. If these have been impractical, as in children for example, general anesthesia has been used. The patient's stomach is pumped before induction of inhalation or intravenous anesthesia and a suction tube is left in the stomach during anesthesia. Food which is present in the stomach at the time of injury will still be there undigested many hours later, as trauma and subsequent shock stop all digestion.

After the establishment of anesthesia, proper preparation of the extremity is under-

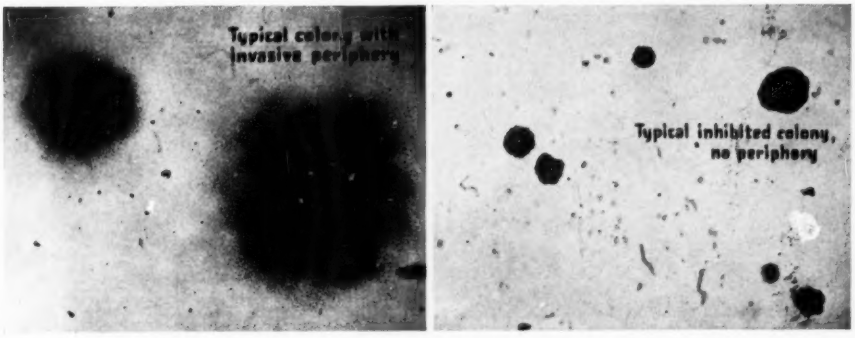


Fig. 2, left. No sulfanilamide. Normal colony development. Note invasive periphery.
Fig. 3. Sulfanilamide. Inhibition of colony development. Colonies much smaller and no invasive periphery.

taken. The wound is covered with a small sterile dressing. The entire limb is washed with sterile soap and water; then shaved. Next the field is washed with alcohol, followed by ether, and finally is painted with any good skin antiseptic. After this preparation, sterile drapes are placed and the gauze dressings over the wound are removed. Again, using sterile soap and water and sterile gloves, the area around the wound is washed, care being taken not to wash dirt into the wound. A sharp scalpel makes an efficient sterile razor and with this the adjacent skin is shaved and the scalpel is discarded. Then this area is painted with antiseptic solution, none being allowed to enter the wound.

Using fresh gloves and instruments, and gowned as for a major procedure, the surgeon excises the skin margin and soiled subcutaneous tissues and picks the superficial gross particles from the wound. This should be done without contaminating one's gloves, and the instruments used should be discarded. Next, the depth of the wound is explored and all soiled and devitalized tissue excised. Loose fragments of bone are removed. Muscle should be cut back until it twitches when touched with the knife. Frayed fascia and periosteum are excised and the soiled ends of the bones are rongeured away. Finally, the wound is carefully irrigated with 5 to 10 quarts of warm normal saline and all waving filaments of tissue removed.

Dry sterile drapes are now placed and, with fresh gloves and instruments, the surgeon again carefully goes over the wound, appraising its viability and cleanliness millimeter by millimeter. Dying muscle, fascia, and bone must be removed for they will inactivate sulfanilamide and furnish an excellent culture media.

Finally sterile sulfanilamide powder is distributed throughout the wound in sufficient quantity to cover all the surfaces (5 to 20 grams) and the wound is closed without tension by interrupted silk sutures in the skin only. Countercutting of the skin and subcutaneous fascia and fat down to the deep fascia well away from the wound will often allow closure without tension (Figure 5). These counterincisions should be placed a

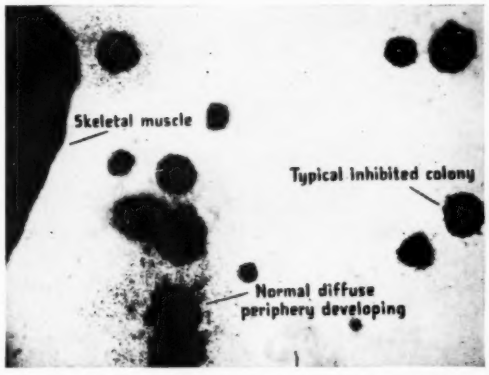


Fig. 4. Sulfanilamide—autolyzing muscle. Effect of fragment of dying muscle on bacteriostatic power of sulfanilamide. Note development of colonies with invasive periphery adjacent to autolyzing muscle, while more distant colonies show typical sulfanilamide inhibition.

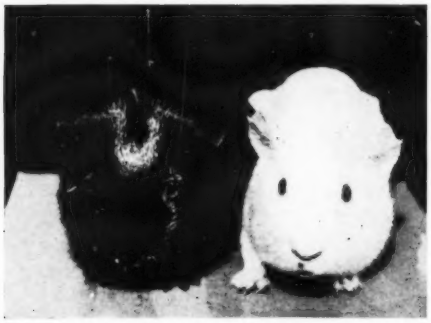


Fig. 5. Photograph of the 2 sacrificed animals of experiment 5 just prior to killing. The black guinea pig is on the verge of death. Note the distention of his neck and chest until it covers his paws. This is due to gaseous emphysema of the soft tissues. The white guinea pig is perfectly well. Both animals were the same size before inoculation (litter mates).

quarter of the circumference of the extremity away from the wound and should be in the long axis of the extremity. They are lightly dusted with sulfanilamide powder, covered with vaseline gauze, and will have healed long before the fracture has united.

If closure cannot be accomplished without tension, a larger amount of sulfanilamide powder (20 to 40 grams) is layered over the surfaces of the wound and covered with vaseline gauze.[1] Plaster is then applied directly over this as in the Orr treatment. If doubt exists as to the efficacy of the débridement or the viability of any part, primary suture should not be attempted.

Treatment of the fracture is next undertaken. Skeletal traction with supporting plaster splints[2] to prevent motion at the fracture site is routinely used in fractures of the tibia, femur, and humerus. Fractures of the forearm are usually handled in plaster splints alone, but occasionally we have used two-pin casts when necessary to accomplish complete stable reduction.- *We do not window casts.* Wounds are not examined or dressed for 3 to 5 weeks unless the clinical symptoms demand it. In this connection it is well to remember that even closed fractures are followed by moderate fever for a few days. Increased local pain with evidence of swelling and rapid pulse is suggestive of gas gangrene and demands immediate inspection; otherwise, dressing or examination of the wound only invites infection.

[1]In our first 41 cases (Surgery, 1939, 6: 1-12), we closed every wound by suture of the skin only. In February of 1939 Dr. J.A. Key of St. Louis, Missouri, became interested in this study. In May of 1939 he told us of several cases which he had been unable to close primarily and which he had successfully treated as outlined above. Since then we have adopted this practice in similar cases.

[2]The method will be described fully in a publication to appear subsequently.

CLINICAL RESULTS

During the years 1932, 1937, and the first 3 months of 1938, the treatment of compound fractures at the Minneapolis General Hospital was identical with that outlined above, except that sulfanilamide was not used. The visiting staff directing the fracture service was the same in each of these years. For this reason we have selected these years, which incidentally were among the most successful prior to sulfanilamide, for comparison with the series treated with sulfanilamide.

A summary of the results which were obtained in these years is given in Tables VI, VII, and VIII.

It will be seen that the incidence of infection was 25.8 per cent in 1932, 27.5 per cent in 1937, and 27.2 per cent in the first 3 months of 1938. During these years a total of 96 compound fractures was treated. Twenty-five of these fractures became infected, 7 of them developed gas gangrene, and 5 secondary amputations were performed to control infection. Average hospital stay for the entire 96 cases was 96.3 days.

From the last of March of 1938 to the first of December of 1941, 212 compound fractures were treated by the local implantation of sulfanilamide in addition to débridement and immobilization (Table IX). In this group, 7 primary and 2 secondary wound infections developed. Two cases of gas gangrene occurred requiring secondary amputation. Both cases resulted from inadequate débridement and irrigation as carried out by inexperienced men. The average hospital stay for this group of patients was 30 days, a reduction of 70 per cent.

Two of these infections occurred from recontamination of the wounds. Both patients in the maniacal stages of delirium tremens recompounded their tibial fractures, one on the 8th day, the other on the 7th day after reduction. In both instances, we simply re-

TABLE VI.—COMPOUND FRACTURES TREATED IN 1932

Method of treatment	Tibiae fibulae		Radii, ulnae		Phalanges metacarpals		Femora		Humeri	
	No.	%	No.	%	No.	%	No.	%	No.	%
	17	54.8	7	22.6	4	12.9	1	3.2	2	6.5
Primary suture	15	88.2	7	100.0	3	75.0	1	100.0	2	100.0
Open wound	1	5.9			1	25.0				
Dakin's	1	5.9								
Cast	12	70.6	7	100.0	3	75.0			1	50.0
Traction	2	11.8					1	100.0	1	50.0
Amputation to control infection	3	17.6								
Traumatic amputation	1	5.9			1	25.0				
Gas gangrene	1	5.9								
Infection	4	23.5	1	14.3	1	25.0	1	100.0	1	50.0

Summary: 31 open fractures, 8 became infected } Incidence of infection, 25.8%

duced the fractures on the ward and applied new plaster splints without any treatment of the wounds. These occurred before we found that clean wounds could be expected if we layered the wound with a thick coat of sulfanilamide powder and loosely packed it with vaseline gauze. We now believe that if we had taken these patients back to the operating room, excised the freshly damaged tissue, then treated them by the open method, we still might have avoided infection. No evidence of infection was present in either case before the recontamination occurred, but promptly after that both patients became febrile and soon pus drained from their wounds.

These 2 cases represent failure in handling the complications of compound fractures. Patients who are showing the prodromes of delirium tremens must be kept adequately sedated, and it is probable that compound tibiae and humeri should always be internally fixed with long, firmly applied vitallium plates at the time of débridement (Fig. 7).

One infection developed under circumstances that duplicated the experiments performed in animals to test the effectiveness of sulfanilamide given systemically or used locally. A patient was admitted with an extensive compound fracture of the upper one-third of the tibia. After completion of a painstaking

TABLE VII.—COMPOUND FRACTURES TREATED IN 1937

Method of treatment	Fibulae tibiae		Radii, ulnae		Phalanges metacarpals		Femora		Humeri	
	No.	%	No.	%	No.	%	No.	%	No.	%
	21	52.5	7	17.5	5	12.5	3	7.5	4	10
Primary suture	17	80.9	6	85.7	4	80.0	2	66.6	3	75
Open wound	3	14.3	1	14.2	1	20.0	1	33.3	1	25
Dakin's	1	4.7								
Cast	5	23.8	6	85.7	4	80.0			2	50
Traction	12	57.1					2	66.6	2	50
Amputation to control infection			1	16.7						
Traumatic amputation	1	4.7			1	20.0	1	33.3		
Gas gangrene			4	57.1	1	20.0				
Infection	5	23.8	3	43.0	2	40.0			1	25

Summary: 40 open fractures, 11 became infected } Incidence of infection, 27.5%

TABLE VIII.—COMPOUND FRACTURES TREATED IN FIRST THREE MONTHS OF 1938

Method of treatment	Tibiae fibulae		Radii, ulnae		Phalanges metacarpals		Femora		Humeri	
	No.	%	No.	%	No.	%	No.	%	No.	%
	14	63.6	3	13.6	1	4.5	4	18.3		
Primary suture	12	85.7	3	100.0	1	100.0	3	75.0		
Open wound	2	14.3					1	25.0		
Dakin's										
Cast	8	57.1	3	100.0	1	100.0				
Traction	8	57.1			1	100.0	2	50.0		
Amputation to control infection	1	7.1								
Traumatic amputation	1	7.1					2	50.0		
Gas gangrene	1	7.1								
Infection	4	28.6					2	50.0		

Summary: 22 open fractures, total 6 became infected } Incidence of infection, 27.2%

débridement, implantation of 5 grams of sulfanilamide and suture of the skin, a small puncture wound was discovered corresponding to a fracture in the lower one-fourth of the fibula. The surgeon closed this wound with only superficial débridement and without sulfanilamide. The tibial wound healed without infection. Osteomyelitis developed in the

TABLE IX.—COMPOUND FRACTURES TREATED WITH LOCAL SULFANILAMIDE
(March 21, 1938 to December 1, 1941)

Method of treatment and complications		Tibiae-Fibulae		Radii, Ulnae		Phalanges Metacarpals Tarsals		Femora		Humeri		Skull 4 Ilium 1 Sternum 1 Other bones 8		Compound dislocations	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
		64	30.2	37	17.4	64	30.2	11	5.2	7	3.3	14	6.6	15	7.1
Primary suture		61	95.3	36	97.3	53	82.8	10	90.0	7	100.0	13	92.8	13	86.6
Sliding grafts		31	48.4	9	24.3	1	1.5	3	27.2	1	14.3	3	21.4	1	6.6
Open wound		3	4.7	1	2.7	11	17.2	1	9.1	0	0	1	7.1	2	13.3
Internal fixation		13	20.3	3	8.1	0	0	2	18.2	1	14.3	1	7.1	0	0
Cast		63	98.4	36	97.3	57	89.0	2	18.2	6	85.7	6	42.8	13	86.6
Traction		45	70.3	3	8.1	12	18.7	5	45.4	5	71.4	0	0	2	13.3
Traumatic amputation		1	1.5	1	2.7	3	4.7	5	45.4	1	14.3	0	0	0	0
Infection*		6†	9.37	1	2.7	0	0	1†	9.1	0	0	0	0	2	13.3
Gas gangrene		0	0	1	2.7	0	0	0	0	0	0	0	0	1	6.6
Amputation to control infection		1	1.5	1	2.7	0	0	0	0	0	0	0	0	1	6.6
Deaths#	15 included	9	14.0	3	8.1	Causes of Death: Head injury 15; Ruptured spleen 3; Fat emboli 3; Multiple injuries 2; Medical causes 4									
	12 not included	12		1											

Summary: 212 open fractures, 7 primary infections } Incidence of infection 3.3%

*Gas gangrene and osteomyelitis, of course, are infection. We also regard as infection a soft tissue process that results in prolonged drainage delaying healing. A wound closing rapidly by secondary intention may be contaminated but it is not infected.

†One of these was not treated with sulfanilamide and hence is not included as an infection in the sulfanilamide group. Two other tibiae subsequently recompounded their fractures and became secondarily infected. These likewise are not included. (See text.)

‡Two femora were internally fixed. One adequately—one inadequately. The latter became infected (see text).

#Deaths. All came to autopsy. Those that lived 5 days or longer after débridement we included in the treated group. All wounds were carefully examined at autopsy and none were found to be infected in this group. Those that died before 5 days were omitted from the study.

fibula. In this case, the circulating sulfanilamide absorbed from the tibial wound failed to prevent infection in the fibula. Furthermore, because of this experience and one which we have observed recently (see footnote, Experiment 5) in which only superficial débridement was done and sulfanilamide stuffed into the deeper wound with the subsequent development of gas gangrene demanding amputation of a youth's right arm, we are convinced that our policy of careful, complete débridement of all compound fracture wounds is imperative. The conception of a so called "minimal" compound fracture is about as sound as if one referred to "minimal" carcinomas and recommended that conservative treatment be carried out for them.

The foregoing 3 cases do not represent *primary* wound infections of compound fractures which were treated with local sulfanilamide. However, they teach in each case a valuable lesson.

Seven primary wound infections did occur, however. These resulted from our failure to establish and maintain in these wounds the local conditions essential for the bacteriostatic action of sulfanilamide.

In 2 compound fractures of the tibia with extensive skin loss, primary closure was attempted. Despite countercutting and the fashioning of sliding grafts, closure of the defect was under considerable tension and the skin flaps developed ischemic necrosis. This autolyzing tissue inactivated the sulfanilamide, and osteomyelitis developed. After several months, amputation was elected in 1 case. It is significant that in both instances the surgeon in his operation report dictated several days before infection became evident, complained that closure had to be accomplished under great tension. We now believe that these cases could be satisfactorily treated by the open procedure.

The third primary infection developing in a compound tibia, we believe, resulted from inadequate immobilization of a fracture in the middle third of the shaft. A junior resident, just after coming on the service, attempted to immobilize this fracture in a confused senile male by means of skeletal traction and a posterior plaster splint only. The absence of an anteromedial splint allowed excessive motion. Maceration of the wound including the sutured skin overlying the ends of the fragments occurred—infection with localized osteomyelitis followed.

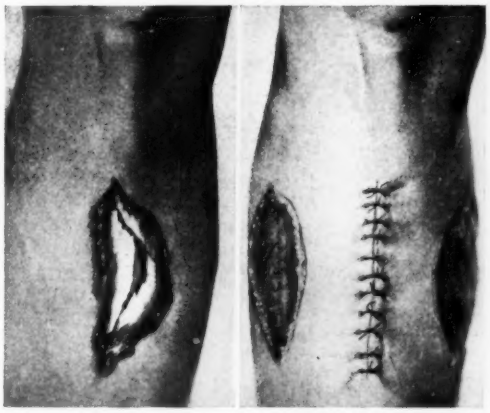


Fig. 6. a, Compound fracture with extensive loss of soft tissue. b, Closure of wound accomplished by liberating lateral incisions. (From Cannady, *Ann. Surg.*, April, 1929.)

The fourth primary infection occurred in a compound fracture-dislocation of the ankle joint. The wound was very dirty, and in an attempt to save articular cartilage not all the soiled surface was cut away. The wound was thoroughly irrigated with the hope that the cartilage would be cleansed sufficiently thereby. Drainage did not occur, but a chronic destructive arthritis has developed with increased local heat, and certainly bacterial infection is present.

Our experimental studies and these cases indicate that no compromise with adequate débridement can be uniformly successful. If dirt visible to the unaided eye is present in the wound, infection will usually follow, regardless of sulfanilamide.

Extensive maceration of muscle presents a real problem—our fifth failure occurred in such a case. A 16 year old boy struck by an automobile sustained compound fractures of both femora. The left wound was not extensive and a satisfactory débridement and closure was readily accomplished with healing *per primam* and prompt union. At the time of débridement the fragments were wired togeth-

er. On the right side an extensive macerated wound had occurred, reaching from above the greater femoral trochanter to the knee and exposing the upper two-thirds of the femur with destruction of the periosteum over the bone. The substance of the vastus lateralis was destroyed by maceration and soiling was extensive. Careful débridement was carried out, but completely adequate hemostasis of the extensive muscle surfaces was never attained. A loop of stainless steel wire was passed through drill holes in the fragments. This accomplished approximation but not immobilization of the fragments. The wound was closed with primary suture of the skin after the surfaces were dusted with sulfanilamide. Infection followed, not extensive, but definite osteomyelitis of the femur with healing of the soft tissues except for a small sinus tract.

It is also apparent now that the internal fixation was faulty. Approximation of two fragments by passing a loop of wire between their ends does just that. It approximates but does not immobilize. The motion of the wire in the bone results in destruction of bone, and this in turn leads to inactivation of sulfanilamide inviting infection.

The sixth and seventh infections represent tragedies. Both were severe Bacillus welchii infections associated with hemolytic streptococci. One followed a compound fracture of both bones of the forearm—the other a compound fracture-dislocation of the ankle. Débridement in both instances was hastily performed and examination of the amputated extremities revealed retained foreign particulate matter.

SUMMARY OF CLINICAL RESULTS

In summary of the clinical results, our overall incidence of infection from all causes in 212 consecutive compound fractures and 15 compound fracture-dislocations is 4.4 per cent. Two of these, however, are distinctly due to secondary contamination of the wound occurring after clean, noninfected wounds had been obtained. One was not treated with sulfanilamide. This leaves 7 cases of primary wound infection—wounds that became infected as a result of their contamination at the time of injury. These we feel represent our true failures, an incidence of 3.3 per cent. The explanation of these infections is readily apparent, and it is also as evident that they could have been avoided by known means. In fact, these failures represent lessons we had to learn about the use of sulfanilamide in compound fractures.

Débridement and *immobilization* remain the basic essentials of successful treatment of compound fractures. Any compromise with either will lead to failure in a tragic number of cases. A débridement is "good enough" only when it has resulted in removal of all the devitalized and soiled tissue. Complete débridement followed by continuous motion at the fracture site is futile, for the continued motion remacerates the wound. Minimum immobilization requires splinting of the joint above and below the fracture. In tibial fractures, a hip spica may often be advantageously used in conjunction with skeletal traction.

Evidence is now accumulating that with careful débridement and local sulfanilamide, internal fixation with vitallium can be safely and perhaps advantageously undertaken. In the last year and one-half a cautious beginning has been made at the Minneapolis General Hospital, and to date (December, 1941) 20 compound fractures have been internally fixed without a single instance of wound infection (Figure 7). Internal fixation with appropriate external support solves the problem of immobilization. However, great care must be taken to insure solid internal fixation, for, if screws loosen and the plate slips, it becomes a damaging foreign body inviting sepsis.

The only sutures that belong in a compound fracture wound we feel are those necessary for hemostasis and nerve repair. We prefer interrupted fine silk (not larger than Deknatel C.) for buried ligatures and sutures as well as skin closure. The studies of Shambaugh and Cutter and Dunphy showing 50 per cent less infection in contaminated wounds sutured with fine silk seems significant.

There has been much confusion in the literature about the treatment of gas gangrene. However, two facts stand out. In controlled experimental infections with various members of the clostridia group, the only

agents which have been found to be of any consistent value are antitoxin and members of the sulfonamide group; and the best treatment that can be offered now is the combination of serum (polyvalent antitoxin) and chemotherapy. Both local and systemic administration of the sulfonamides should be used. Sulfathiazole should be given systemically and a mixture of one part sulfathiazole with two parts sulfanilamide appears from Hawking's studies to be the best for local use. Serum should be given in adequate amounts early (100,000 international units or more). Even with these agents, active surgical measures must be pursued and amputation done before disaster results from temporizing débridement of the obviously involved muscle.

Prevention of these infections is the only really satisfactory solution. Every surgeon who treats traumatic wounds should constantly remember that gas gangrene will not develop unless he leaves behind macerated or ischemic muscle, foreign material (dirt), or large numbers of virulent invasive aerobes. The clostridia alone cannot invade clean viable tissue. If adequate débridement is done and sulfanilamide powder is then implanted in the wound, aerobic infection is unlikely and gas gangrene will not occur. Even so, we believe that prophylactic antigas gangrene serum as well as tetanus antitoxin should be routinely used.

Finally, we wish again to emphasize that sulfanilamide locally implanted is effective only under rather rigid conditions. These conditions can be established by careful radical débridement within 6 to 8 hours after injury, complete immobilization, and appropriate measures to maintain good circulation and body temperature, or slightly above, in the wound. It may be that even under adverse military circumstances, the severity of infections will be greatly lessened by prophylactic local sulfanilamide. There is yet, however, no incontrovertible data on this phase of the problem, although the observations of Leonard Colebrook and many others (2, 10) in England seem to support this view.

The possibility that one of the new sulfonamide compounds will be found more effective as a local prophylactic agent is good, and this phase of the problem is under investigation. The studies of Dubos on antibacterial substances liberated by sporulating soil bacilli, and of Chain of England of the antibacterial substance elaborated by a mold closely related to Penicillium notatum offer very great possibilities which demand investigation.

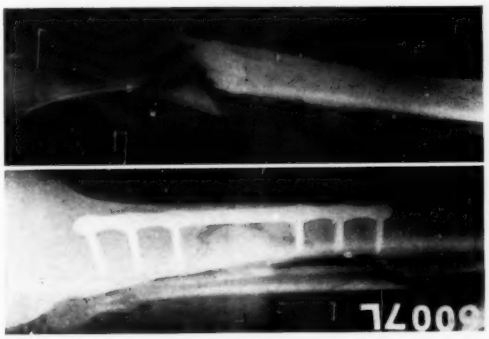


Fig. 7. Roentgenograms of a compound fracture of a tibia before and after débridement and reduction with internal fixation. Vitallium plate and screws used. Note length of plate and selection of screws so that each screw transverses both cortices of the tibia.

SUMMARY

1. The basic treatment of compound wounds is débridement and immobilization.

2. The addition of local sulfanilamide implantation to this basic treatment reduced the incidence of infection in compound fractures treated at the Minneapolis General Hospital from approximately 27 per cent to 3.3 per cent.

3. Local implantation of sulfanilamide in compound fractures reduced the average hospital stay per case from 96.3 to 30 days.

4. Two cases of gas gangrene occurred, less than 1 per cent, in 212 consecutive compound fractures treated with local sulfanilamide, while 7.3 per cent of the control series treated without sulfanilamide developed gas gangrene.

REFERENCES

1. Brown, James L. Brit. M. J., 1937, 1:1157.
2. Buxton, J. D. Brit. M. J., 1940, 2:802-803.
3. Chain, E., Jennings, H. W., Florey, J., Orr-Ewing, Heatley, N. C., Sanders, A. G. Lancet, Lond., 1940, 2:226–228.
4. Colebrook, Leonard. Lancet, Lond., 1940, 2:113–114.
5. Cutter, Elliot C., and Dunphy, John E. N. England J. M., 1941, 224:101–106.
6. Dubos, R. J. Ann. Int. M., 1940, 13:2025–2037.

7. Hawking, Frank. Brit. M. J., 1941, 1:263–268.
8. Hurteau, Everett F. Canad. M. Ass. J., 1941, 44: 352–355.
9. Jaeger, von Karl-Heinz. Deut. med. Wschr., 1935, 62:1831–1835.
10. Jeffrey, J. S. Edinburgh M. J., 1940, 47:727–742.
11. Jensen, N. K., Johnsrude, L. W., and Nelson, M. C. Surgery, 1939, 6:1–12.
12. Key, J. A., and Burford, T. H. South. M. J., 1940, 33:449–455.
13. King, J. T., and Henschel, Austin F. Proc. Soc. Exp. Biol., N. Y., 1939, 41: 208–209.
14. Legroux, R. Mém. Acad. chir., Par., 1940, 66:415–424.
15. Marshall, E. K., Jr., Emerson, Kendal Jr., and Cutting, W. C. J. Am. M. Ass., 1937, 108:953–956.
16. Merz, Hans. Schweiz. med. Wchnschr., 1937,67: 342.
17. Neter, Erwin. Proc. Soc. Exp. Biol., N. Y., 1940, 43:52–54.
18. Nitti, F. Bull. Acad. méd., Par., 1939, 32:432–435.
19. Orr, H. Winnett. Arch. Surg., 1940, 40:825–838.
20. Russell, Dorothy S., and Falconer, Murry A. Lancet, Lond., 1940, 2:100.
21. Shambaugh, Phillip. Surg. Gyn. Obst., 1937, 64:765.
22. Spink, W. W. J. Immunol., 1939, 37:345–358.
23. Tiling. Muench. med. Wschr., 1936, 83:952.
24. White, Harold J. J. Bact., Balt., 1939, 38:549–560.
25. Woods, D. D. Brit. J. Exp. Path., 1941, 21:74–89.

PULSATING TUMORS OF THE ANTERIOR MEDIASTINUM

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A NEOPLASM that arises in the anterior mediastinum and erodes through the sternum by transmitted pulsation from the aorta is extremely rare. Sir James Paget, in 1896, stated that "malignant disease of the chest wall receiving pulsation from the heart has been mistaken for aneurysm. The converse error has also been committed."[1]

The most common origin of a pulsating mass in the sternum is an aneurysm of the aorta. Aneurysms of the internal mammary artery also occur and may erode the adjacent bone, but such erosions are usually along the margin of the sternum and the adjoining costal cartilage. It is, of course, conceivable that an aneurysm of this vessel may project to its median side and perforate the sternum.

In an excellent study of pulsating tumors of the sternum George Crile, Jr., states that no verified case of pulsating sarcoma of the sternum could be found in the literature. It is well known, however, that pulsating sarcoma of bone, the so called bone aneurysm, occurs elsewhere. Crile reports 13 cases of pulsating neoplasms of the sternum that have been reported in the literature, and adds 5 more from the records of the Cleveland Clinic. Of this entire group 9 were probably cases of metastatic hypernephroma, or adenocarcinoma of the kidney as it is now termed, and 9 were probably metastases from malignant adenomas of the thyroid.

The following case of pulsating tumor involving the sternum, though not originating in the sternum, presents unusual and interesting features:

CASE REPORT

C. L. G., white male, 74 years of age, was admitted to St. Elizabeth's Hospital on July 8, 1940, complaining of a pulsating growth in the upper sternum, slightly to the right of the midline. He first noticed it about 4 months prior to admission. It had gradually increased in size. It had never been tender or painful.

Dr. Roy W. Upchurch, of Danville, Virginia, had performed a left nephrectomy on the patient on May 23, 1933. There was an impacted stone in the lower third of the left ureter. The kidney was a pyonephrotic sac full of pus. There was no evidence of malignant neoplasm. On July 10, 1933, Dr. Upchurch had done a transurethral resection of an enlarged middle lobe of the prostate. The pathological report on the tissue removed showed no cancer but hyperplasia and chronic prostatitis. The patient made a satisfactory recovery from both operations.

Physical examination. The patient was in fairly good general condition. Wassermann reaction was negative. Blood and urine were about normal. There was a pulsating mass over the upper manubrium slightly to the right of the midline. The pulsations were expansile and synchronous with the heart beat. There was no bruit. The tumor was about 6 centimeters in diameter and 4 centimeters in elevation (Figs. 1 and 2). There were no definite heart murmurs; blood pressure was 170/95, and equal in both arms. Roentgenological examination showed a defect in the upper manubrium. The defect was smooth in outline and about 5 by 4 centimeters in diameter (Fig. 3).

Dr. Fred M. Hodges, who made the roentgenological examination, thought the lesion was probably a tumor of the anterior mediastinum. The heart and aorta seemed normal under the x-rays. The expansile pulsations were so obvious that I made a tentative diagnosis of aneurysm of the right internal mammary artery.

Operation under ethylene anesthesia was performed on July 10, 1940. After an incision through the skin and fascia over the tumor, pulsation diminished and ceased completely when some of the surrounding bone was removed (Fig. 4). Pulsation had evidently been transmitted from the aorta through the tumor. The tumor was soft and had been firmly held by the fascia. As much of the growth was removed as possible, but it was rather extensive and bled so freely that some of the posterior part of the tumor was left. Five radium needles, each containing 10 milligrams of radium, were inserted, and iodoform gauze was firmly packed into the wound. The wound was partly sutured over the gauze.

The specimen consisted of a large portion of the tumor and other smaller portions. The largest portion measured 5 by 4 by 2.5 centimeters. Its external surface was covered with an apparent capsule which was really fascia and muscle that the growth had pushed forward. The main substance of the

From the Surgical Department of St. Elizabeth's Hospital, Richmond, Virginia.

[1] Paget, Sir James: The Surgery of the Chest. Bristol, 1896; quoted by Crile, George, Jr. Ann. Surg., 1936, 103:199–209.

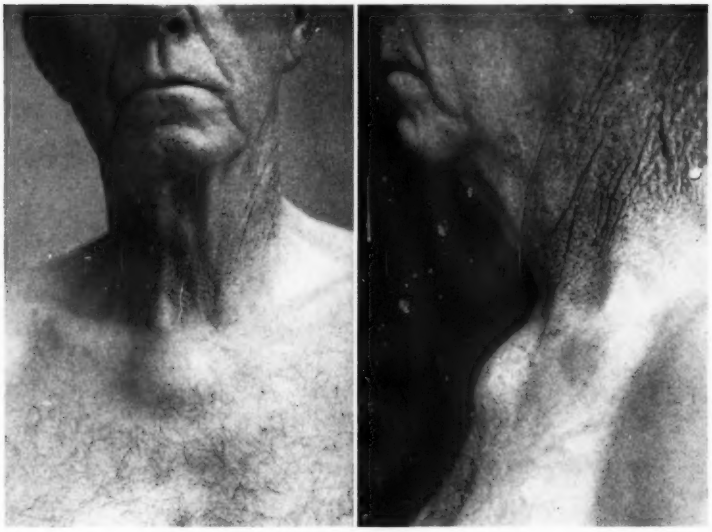

Fig. 1, left. Photograph of pulsating tumor of the anterior mediastinum, slightly to the right of the midline.
Fig. 2. Lateral view of pulsating tumor of the mediastinum.

tumor was soft, almost jelly-like, and of a pale yellow color. Adherent to its outer surface were several spicules of bone which became attached as the tumor eroded through the sternum. There were three other pieces of the tumor. The largest of these measured 3 by 2.5 by 1.5 centimeters. Microscopically, the tissue consisted chiefly of epithelial cells with very scant stroma. The cells varied in size and shape: round, polyhedral, cubical, or columnar. Throughout most of the microscopic field the cells were arranged in acinus-like formation. Occasionally, the acini were quite distinct and contained large, clear, columnar cells. Other portions of the field showed the cells packed rather closely together. In many areas the cells resembled somewhat those of an adenocarcinoma of the kidney, with almost clear cytoplasm and a small nucleus. The cytoplasm usu-

Fig. 3. Sketch from the x-ray picture showing outline of the erosion in the manubrium.

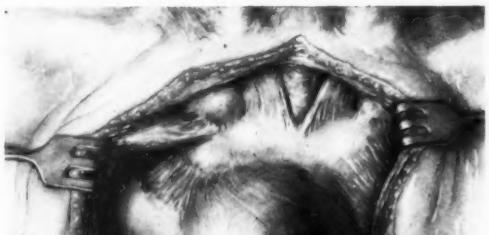

Fig. 4. The tumor with its covering of fascia and muscle has been exposed at operation.

Fig. 5. Photomicrograph of tumor. It shows the structures described in the text with the acinous formation, clear cells and other cells packed in close formation. ×150.

ally was slightly granular. There were a few clear cells without nuclei, such as are found in the so called hypernephroma. The tumor was undoubtedly malignant. The histological structure did not clearly indicate its origin (Figs. 5, 6, and 7). Some pathologists thought it was a metastatic hypernephroma from the kidney even though it showed acini. It would be unusual to find a single metastasis at some distance from the original lesion with no metastases elsewhere. Such a thing is possible but not probable. Dr. A. C. Broders called the tumor an adenocarcinoma, grade 3, but was uncertain as to its origin. There was no evidence of an origin in the bone. The margin of the bone removed in order to obtain access to the growth seemed normal in structure. There was merely erosion as a result of the pressure of the tumor.

Subsequent course. Two days later, when the radium and packing were removed, there was profuse bleeding which was controlled by packing with iodoform gauze. An attempt was made to remove the gauze 5 days after the operation, and there was again active bleeding, so the wound was opened and the vessels were controlled by sutures.

One week after the operation x-ray therapy by Dr. Hodges was begun. There were 7 treatments. As the lesion was rather superficial, instead of using

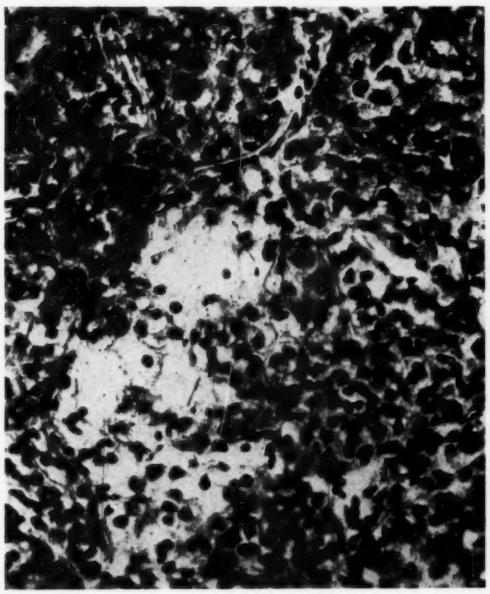

Fig. 6. Photomicrograph showing blocked off area on the left side of Figure 5 enlarged to ×300. Note the clear cells and at the top an acinous formation.

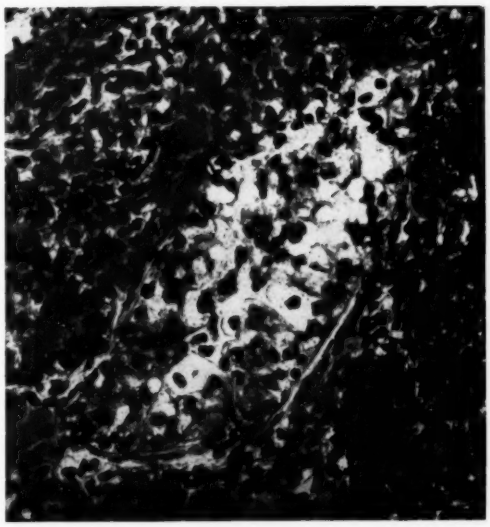

Fig. 7. Higher magnification, ×300, of the blocked off area on the right side of Figure 5. Note the distinct acinous formation of columnar cells with slightly granular and almost clear cytoplasm. The surrounding cells of different sizes and shapes are packed rather closely together.

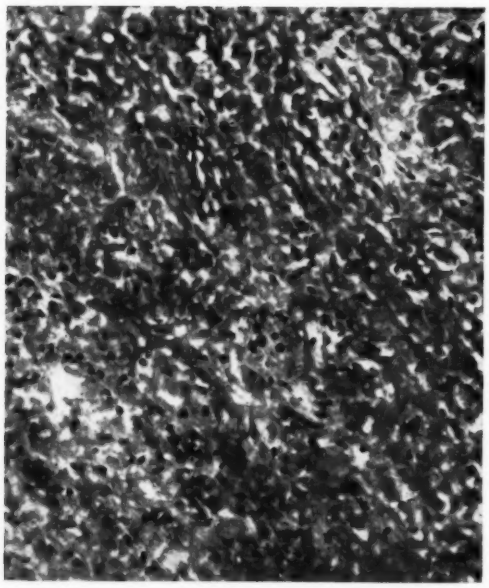

Fig. 8. Photomicrograph of tissue obtained at biopsy from the depth of the wound about 4 weeks after the roentgenological treatment. This shows practically complete degeneration of the neoplastic cells. ×210.

deep therapy the patient was given 130 kilovolts—6 millimeter aluminum filter, 70 minutes—approximately 1800 roentgens. The patient was transfused with blood three times. He was discharged from the hospital 1 month after the operation.

He returned 3 weeks later when he was in fairly good condition. The wound had not healed. There was no pulsation. Biopsy from the wound showed extensive degeneration of the neoplastic cells obviously caused by the irradiation (Fig. 7). The cavity left after the operation was large. Efforts to close it were made by sliding flaps from adjacent tissue. On discharge from the hospital the wound was almost healed. The granulations seemed healthy. On December 5, 1940, the patient again returned and a further plastic operation was done.

A letter received from the patient's family physician, Dr. Girard V. Thompson, of Chatham, Virginia, dated November 22, 1941, states that there is no evidence of any recurrence of the tumor, and that the patient's general health is good. The wound, he writes, has almost healed but occasionally a sinus opens from which spicules of bone are extruded. At operation a portion of the sternum and the inner end of the right costal cartilage of the second rib were removed.[1]

[1]Thorough check-up of patient April 9, 1942, by x-ray and other examination reveals no evidence of recurrence, general health good, chest and mediastinum perfectly clear.

Morris and Harken[2] report several cases in which the diagnosis of a so called Pancoast tumor seems to be substantiated. Pancoast, in 1933, described an intrathoracic growth which he termed a superior pulmonary sulcus tumor. The distinctive features of this tumor are that it is located in the posterior thoracic inlet adjacent to the pulmonary apex; the histological structure is that of an "epidermoid carcinoma"; the site of origin is demonstrably independent of the neighboring lung, pleura, ribs, vertebrae, mediastinum, or metastatic foci. Clinically, according to Pancoast, this tumor produces Horner's syndrome, which the writers show is really Hare's syndrome, for Hare described this symptom complex in 1869, 31 years before Horner did. This neoplasm also causes pain referred to the shoulder and arm, associated with muscular atrophy, and there is roentgenological evidence of a small homogenous apical shadow suggestive of destructive infiltration of contiguous ribs and vertebrae. Morris and Harken conclude that there may exist at the pulmonary apex an epithelial neoplasm which fulfills these specifications and is entitled to be classed as a clinical and pathological entity.

Pancoast believes that there are persistent rests from the ectodermal portion of the branchial structures which serve as primordial origin for the neoplasm he describes.

According to Jordan and Kindred[3] the parathyroids arise from the upper portion of the third and fourth branchial pouches, the thymus comes from the third branchial pouch, and the lateral primordia of the thyroid gland are in the fourth branchial pouch. Below the fifth branchial arch are the ultimobranchial groove and body, a region of romance for the origin of unusual tumors. It would seem, then, that if the Pancoast tumor, which Morris and Harken confirm as a pathological and clinical entity, does arise in the upper thorax from a branchial rest and is always composed of a squamous type of epithelium, there may also be a tumor, as the one herewith reported, originating in rests from the portions of the branchial grooves or pouches that give entodermal or

[2]Morris, John H., and Harken, Dwight E. Ann. Surg., 1940, 112: 1–21.

[3]Jordan, Harvey E., and Kindred, James E. A Textbook of Embryology. New York: D. Appleton and Co., 1926.

columnar and cubical epithelium. Such rests might be from the lateral primordia of the thyroid from the fourth branchial groove, from the third branchial pouch which forms the thymus, or from the third and fourth branchial pouches from which the parathyroids arise. This does not necessarily call into consideration the ultimobranchial transient structures.

CONCLUSION

No positive statement as to the exact histological origin of this unusual neoplasm seems possible now. If the Pancoast tumor is accepted as arising from a primordium of one of the branchial structures carrying squamous epithelium, it would be probable that this tumor could arise from a branchial primordium of columnar or cubical epithelium. If it be assumed that the histological origin of the tumor is from the thymus, it would naturally originate from the early stages of the thymus in which the structure is epithelial and before it has been taken over by the lymphocytes.

SUBPHRENIC ABSCESS WITH BRONCHIAL FISTULA

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THE too obvious deduction that cough with production of large amounts of sputum is evidence of primary intrathoracic disease is a frequent cause of serious diagnostic errors. It is not always known and, if known, is not easily remembered, that hepatic, subdiaphragmatic, and perinephritic abscesses frequently perforate the diaphragm and are evacuated by expectoration. While a few patients are cured by such spontaneous drainage and while some others die early from spreading pulmonary or pleural infection, in many instances the condition becomes chronic and the patient, partially recovered, is left with a persistent or intermittent productive cough. The purpose of this paper is to report 3 cases of chronic subdiaphragmatic abscess with bronchial fistula.

It is a paradox of pathology that collections of pus in the upper abdomen frequently burrow upward through the diaphragm whereas similar collections in the thorax rarely, if ever, extend downward into the abdomen. In a series of 3,608 cases of subphrenic abscess collected by Ochsner and DeBakey, there were only 89 in which pleural or pulmonary infection was believed to have been primary. There were none in the authors' 75 cases. Inasmuch as the first important symptoms and signs of subdiaphragmatic pus are often those incident to extension to the pleura or lungs, and inasmuch as this entity is frequently mistaken for pleurisy, pneumonia, or lung abscess, it is reasonable to believe that in many of the 89 cases reported the subdiaphragmatic did actually precede the supradiaphragmatic lesion. It is quite possible that downward extension does not occur.

In 1937 Steele reported 6 cases of subdiaphragmatic abscess with bronchial fistula and reviewed the literature. In 1902 Cauderay was able to collect 20 cases, and in 1909 Piquand, in a collected series of 890 cases of subphrenic abscess, found 112 with diaphragmatic penetration and bronchial evacuation, an incidence of 12.6 per cent. Between 1909 and 1937 Steele found records of 13 additional cases. In 1938 Ochsner and DeBakey analyzed 3,608 collected cases of subdiaphragmatic abscess. In 1,380 cases in which information was sufficiently detailed simple pleurisy occurred in 27.7 per cent, perforation with empyema in 17.8 per cent, perforation with bronchial fistula in 10.5 per cent, and perforation with pericarditis in 5.1 per cent. The total incidence of perforation of the diaphragm was 33.4 per cent. There were 2 instances of spontaneous evacuation through the chest wall.

The serous, sterile pleural effusions which occur in many cases—27.7 per cent in Ochsner and DeBakey's series—are not evidence of perforation and are not of great clinical significance.

The incidence of perforation of the diaphragm is so high that this complication is to be expected when operation is too long delayed. Ochsner and DeBakey stress the fact that thoracic complications are definitely attributable to late diagnosis or to procrastination in treatment. While this statement is largely correct, it is not entirely so. In Cauderay's 20 cases the interval between the etiological disease or operation and the perforation varied between 10 days and 23 months. In Steele's cases the limits were 13 days and 18 months with an average interval of 18 weeks. It is evident that in occasional cases perforation occurs early.

CLINICAL PICTURE

The perforation of a subdiaphragmatic abscess into a bronchus is usually sudden. A patient who has presented the picture produced by encapsulated pus suddenly starts

From the Thoracic Surgery Service of the Veterans Administration, Hines, Illinois.

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coughing and in the course of a few minutes expectorates a large quantity of pus. This is always a difficult and trying experience and is occasionally more than a debilitated patient can survive. Sudden death from drowning may occur. Flooding of the lungs with pus may produce a progressive and fatal bronchopneumonia. If the patient survives these immediate hazards he is usually benefited by the drainage of the abscess. The fever may fall to normal, cough and expectoration may gradually subside, and spontaneous complete recovery may occur. This is rare, only 3 such cases having been reported. More often the patient continues in a more or less septic state and with persistent cough and expectoration. Not infrequently the abscess drains intermittently. When the tract becomes plugged, cough and expectoration cease, and the temperature rises. Such spells are usually followed by re-rupture of the abscess. Between spells of plugging of the tract the temperature may be nearly normal.

The physical findings vary greatly and rarely give a clue to the diagnosis. Evacuation of the pus permits the diaphragm, which before rupture is usually high, to resume its normal position. It also relieves the pain and deep tenderness which are important findings in acute subdiaphragmatic abscess. These may recur if the drainage becomes temporarily stopped. Hoover's sign, an increased movement of the lower ribs on the affected side, disappears with the descent of the diaphragm. One's belief that the symptoms are caused by pulmonary disease may be strengthened by finding signs of scattered areas of pneumonitis which are secondary to the purulent expectoration.

ROENTGENOGRAPHY AS AID TO DIAGNOSIS

Next to the history, the roentgenogram gives the most important diagnostic information. The most characteristic finding is a greater or lesser elevation of the diaphragm with air and a fluid level beneath it. Neither the elevation nor the air and the fluid level are always present. There may be no more than evidences of old pleurisy at the base. The findings in the lungs and pleura above the diaphragm vary greatly. The perforation may have produced an empyema as well as a bronchial fistula (as in one of Steele's cases) in which situation the picture is that of empyema with bronchial fistula. In acute cases there may be extensive bronchopneumonia in the lower lobe on the affected side. In more chronic cases, areas of chronic pneumonitis may be present in one or both lungs. Not infrequently pulmonary and pleural findings are almost entirely absent, consisting merely of increased peribronchial markings extending into one lower lobe. The meagerness of thoracic findings in the presence of fever and copious expectoration is one of the important diagnostic points. In such cases it is necessary to employ bronchography to rule out bronchiectasis; but when this has been done and one is still unable to explain the abundant expectoration on the basis of revealed pulmonary or pleural pathology, it is well to consider the possibility that the pus is coming from below the diaphragm.

When patients are seen later in the course of the disease, it is important to gain access to all of the x-ray films which have been taken. Those taken before or immediately after the perforation may present characteristic findings.

If there is much pleural thickening at the base of the thorax, only x-ray pictures taken with heavy penetration will reveal air or fluid below the dome of the diaphragm.

DIAGNOSTIC PNEUMOPERITONEUM

X-ray pictures taken after the injection of 300 to 400 cubic centimeters of air into the peritoneal cavity are of great value. Under normal conditions with the patient in the upright position, these will reveal air beneath both halves of the diaphragm. In the presence of subdiaphragmatic abscess, no air can penetrate into this space on the affected side. If the under surfaces of the diaphragm are free, pus in this region can be ruled out.

The induction of pneumoperitoneum is an extremely simple and safe procedure. One simply thrusts a blunt pneumothorax needle (Kuss needle) well through the parietal peritoneum below the left costal margin and permits the air to flow in from a pneumothorax apparatus. With the blunt needle there is no

Fig. 1. Case 1. Chronic subdiaphragmatic abscess with bronchial fistula of 12 years' duration. The slightly elevated, fixed right diaphragm with basal lung findings insufficient to account for the copious sputum, suggested the diagnosis. Condition followed operation for ruptured peptic ulcer.

danger of injuring the bowel. If the needle is not in the free peritoneal cavity the air will not flow. One can verify the fact that the air is entering properly by noting the rapid disappearance of the liver dullness.

EXPLORATORY ASPIRATION

In acute unperforated subphrenic abscess exploratory aspiration is dangerous. It is practically impossible to reach the pus without passing the needle through the free pleural cavity. Leakage of pus into this space may cause acute empyema. In a chronic abscess which has already perforated the diaphragm, one can assume that the layers of the pleura are adherent and can use the exploratory needle with impunity. Operation should not be undertaken until the pus has been thus located. Localized tenderness and the x-ray film, especially that taken in the lateral position, will usually indicate the probable site.

PROGNOSIS

In Steele's series of 48 cases of subphrenic abscess seen at the University Hospital at Ann Arbor, the mortality was 50.8 per cent. Of the 6 patients with bronchial fistula 3 died, a mortality of 50 per cent. In the Ochsner and DeBakey personal series, the mortality in those with thoracic complications was 50 per cent as against 16.3 per cent in the uncomplicated abscesses.

TREATMENT

Only 2 of the many reported cases of subphrenic abscess with bronchial fistula are known to have recovered spontaneously. In these, health was regained only after a long and debilitating illness. The event is so rare that it should never be expected or operation delayed in the hope that it will occur. The treatment is the same as that of uncomplicated subphrenic abscess; namely, incision and drainage. In these cases the pleurae are usually adherent and in a single stage one may go directly to the pus at the point where it is nearest to the chest wall and where it has been located by the needle.

CASE REPORTS

CASE 1. A 51 year old police officer entered the hospital on January 24, 1940, complaining of a cough productive of large amounts of foul smelling sputum, fever, loss of weight, and weakness. In 1928 he was operated upon for a ruptured peptic ulcer. Following this he continued to run a fever for some time and did not regain his weight and strength. He had been chronically ill ever since, having pain in the right upper quadrant of the abdomen and right lower thorax. Because of these persistent symptoms and recurrences of fever, he was again operated upon in 1931 for relief of adhesions. This did not relieve his symptoms. In 1934 he was operated upon for gallbladder disease. More adhesions were freed, but the gall bladder was found to be normal and was neither drained nor removed. Since then he had continued in poor health and had had frequent attacks of fever, the temperature occasionally rising to 101 and 102 degrees. In October, 1939, he became acutely ill with a lung condition which his physician called pneumonia.

Examination revealed a rather poorly nourished white male, semiambulant and appearing acutely ill. The right side of the chest was less mobile than the left, the abnormal physical findings being limited to the base of the right lung where vocal fremitus was diminished anteriorly, resonance diminished at the base anteriorly and in the midaxillary line, and with marked diminution of breath sounds and whispered and spoken voice conduction in this area. No râles were heard.

The anteroposterior and lateral x-ray films taken January 30, 1940, revealed an extremely high right diaphragm with some thickening of the pleura above it and some residuals of lipiodol still in the bronchi. This lipiodol examination was made elsewhere. There was a uniform opacity about 1 inch across extending from the diaphragm up the lateral chest wall for

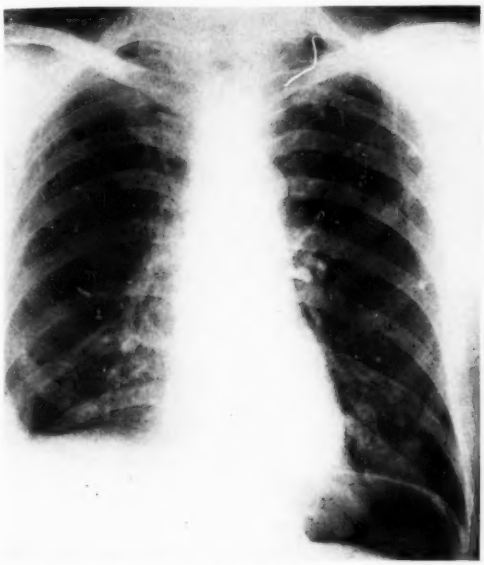

Fig. 2. Case 2. The fixed right diaphragm with minimal pulmonary findings insufficient to account for the copious expectoration suggested the diagnosis. Diagnostic pneumoperitoneum has been performed. There is air beneath the left diaphragm but none beneath the right. This is corroborative evidence of a subdiaphragmatic lesion.

Fig. 3. Case 2. Lateral film showing opacity under anterior part of right diaphragm.

about 2 inches and then bulging outward into the lung field, where on the upper surface it shaded off into normal findings. This had the appearance of fluid in the pleural cavity. On the lateral film the residuals of lipiodol could be seen outlining a high right diaphragm.

Thoracentesis was done over the seventh rib in the nipple line, right, and at a depth of 3½ inches sour smelling pus was obtained. With the patient flat on his back and under local anesthesia, a 2 inch segment of the seventh rib in the nipple line was resected. Cautious layer by layer incision revealed an adherent pleura and also revealed the fact that the incision was being carried through the diaphragm. Aspiration was done through the periosteal bed and similar sour smelling pus was found. A knife was inserted along the shaft of the needle and a large pocket of pus was entered. The opening was enlarged by spreading by a blunt hemostatic forceps. Digital examination revealed a large abscess cavity situated below the diaphragm and extending beyond the reach of the examining finger posteriorly. The size of the cavity could be approximated roughly as being about as large as a grapefruit. As much pus as possible was evacuated, and a large drainage tube was inserted. The wound was packed wide open with mercurochrome gauze.

Case 2. This patient had had a peptic ulcer for many years, the diagnosis having been made by several physicians. He gave a history of having been treated for this ulcer ever since his service in the World War. During the first part of December, 1936, while drinking a cup of coffee in a restaurant, he was suddenly seized with an acute, knife-like pain in the abdomen. This pain came on about 5:30 p.m. He was taken to a hospital and operation was performed at 12 o'clock midnight. A ruptured gastric ulcer was found. What treatment was applied at the time of operation is unknown. The patient said that he had been free from symptoms referable to his stomach since the operation. He reported that several drainage tubes were left in the abdominal wound.

About 30 days after the operation the patient developed a severe pain in the lower right side of his chest and about the same time developed pain at the point of his right shoulder and the right side of the neck. These new pains did not cause any particular concern among his medical attendants and continued uninterrupted and unchanged. Shortly after the onset of these pains he developed a dry cough.

The drainage tubes were removed from the abdominal wound in April and by the latter part of May the wound was completely healed. Sometime during this interim, during a spell of coughing, the patient said he raised a plug of dark, reddish-brown material which he likened in shape to a section of toothpaste squeezed from a tube. Following the bringing up of this plug he raised brownish chocolate sauce material

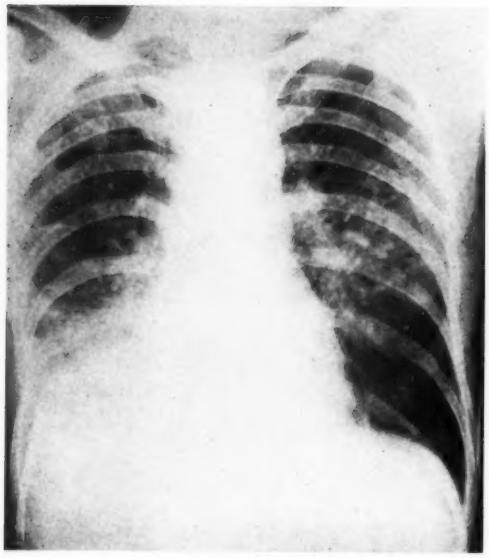

Fig. 4. Case 3. Subdiaphragmatic abscess with bronchial fistula 6 months following probable perforation of a peptic ulcer. There is an opacity and a cavity with fluid level at the base of the right thorax. There are scattered parenchymal infiltrations throughout both lungs.

freely and continued to do so until his admission to this hospital January 25, 1940.

The patient had been able to work only at intervals during the years succeeding his operation and noticed that as long as he raised the chocolate sauce material freely he did not have any fever and felt fairly well, but when his expectoration stopped his temperature rose and he felt ill. The amount of this material varied from time to time from one-half sputum cupful to several sputum cupfuls daily.

Physical examination revealed a poorly nourished but not acutely sick white male, 46 years of age. The physical findings in the lungs were those of slight dullness at the extreme right base in the axilla and posterior, decreased breath sounds in this area, and coarse moist râles. There was a scar of an upper right rectus incision in the abdomen. There was some slight tenderness to palpation in the right upper quadrant of the abdomen.

X-ray examination of the chest revealed a slight increase in peribronchial markings in the right lower lung field with many adhesions at the right half of the diaphragm and complete obliteration of the costophrenic angle.

The red blood count was 3,700,000; white blood count, 8,200; hemoglobin, 75 per cent; polymorphonuclears, 70 per cent; lymphocytes, 25 per cent; monocytes, 40 per cent; and eosinophiles, 1 per cent. The patient had no rise in temperature at the time of examination.

The absence of any definite pulmonary pathological process was evidenced by the x-ray film, the adhesions and fixation of the right half of the diaphragm, and the fact that these symptoms followed operation for ruptured peptic ulcer suggested that this sputum was coming from below the diaphragm and that the lesion was either a subdiaphragmatic abscess or an amebic abscess of the liver. It seemed possible that the operation was made on a mistaken diagnosis and that amebic hepatitis was the cause of his original symptoms and of those which had persisted since the operation. In favor of this diagnosis was the bloody, catsup-like character of the sputum. Against it were the absence of fever and the fairly definite history of peptic ulcer.

A search for ameba in the stools was negative. Pneumoperitoneum revealed that the under side of the left diaphragm was free but that no air entered between the right diaphragm and the liver. This was further corroboration of the belief that the lesion was below the right diaphragm. The lateral film showed a marked elevation of the anterior part of the right diaphragm. A needle was inserted over the 7th rib in the anterior axillary line and about 75 cubic centimeters of reddish, chocolate-brown material were aspirated. This material showed no ameba but did show streptococci.

On several courses of emetine therapy the patient did not improve appreciably. Multiple aspirations failed to relieve his symptoms. Operation was decided upon and a segment of the 7th rib in the anterior axillary line was resected. Incision through the rib bed led into a shallow subdiaphragmatic pocket holding about 250 cubic centimeters of yellowish pus. A rubber drainage tube was inserted and the edges of the wound were packed open.

Case 3. This patient entered the hospital October 28, 1940, complaining of loss of weight, loss of appetite, fever, cough, and expectoration of large quantities of very foul smelling pus. He stated that prior to mid-April, 1940, he had been perfectly well, without any illness of any kind. On or about the 16th or 17th of April, while driving his car and eating some hamburgers, he became nauseated and vomited. A few hours after this he developed a sudden, severe pain in the lower part of the abdomen. This pain did not change location. He was examined by his physician and sent to the hospital in his home town where roentgenograms of his abdomen were taken 5 days after the onset of his pain. These x-ray films indicated the presence of a large gas bubble under the right leaf of the diaphragm. No operation was done for the patient at that time, the treatment consisting of bed rest and symptomatic therapy. About 6 weeks after he was admitted to the hospital his pain in the right lower quadrant had disappeared, and the patient was discharged from the hospital.

He went to the country where he rested for 6 weeks, during which time he regained 18 pounds of his lost weight, but never felt quite well. In mid-August of 1940 the pain in the right lower quadrant returned with the same severity as it had had in the

Fig. 5. Case 3. Lateral roentgenogram showing the accumulation of air and of pus beneath the posterior part of the right diaphragm.

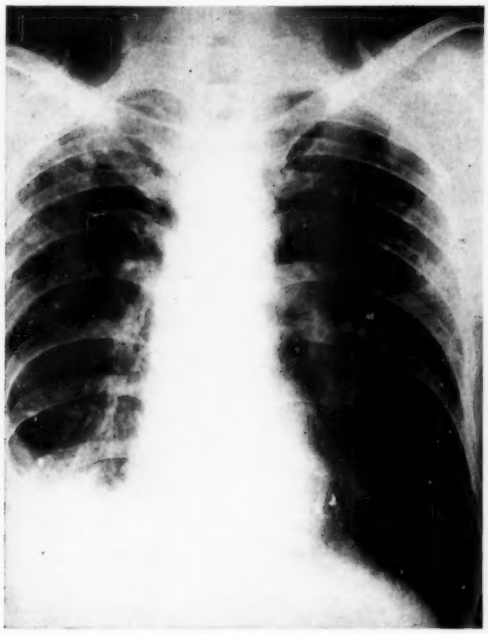

Fig. 6. Case 3. Condition after operation. Note that the parenchymal infiltrations throughout both lungs have almost disappeared.

first place. He returned to the same civilian hospital where he stayed for about a week. While in the hospital the second time he began to cough up greenish, foul smelling pus. He returned to his home where he remained about 4 weeks, during which time he continued to expectorate 3 or 4 cupfuls of extremely heavy, foul smelling pus daily.

At the time of admission to this hospital for treatment, the patient was very poorly nourished, running an irregular temperature with moderately high afternoon elevations. He was raising one-half cupful of foul smelling sputum daily. X-ray films showed an air bubble beneath the right leaf of the diaphragm which contained a fluid level. Patient was tender under the right costal arch.

Due to the long duration of the infection, it was felt that there were dense adhesions between the pleura and the diaphragm. Accordingly, the patient was taken to the operating room and a 3 inch segment of the 11th rib, posterior, right, beginning 2 inches from the spine, was resected. The periosteal bed was found to be thickened and fibrosed. The aspirating needle was passed through the bed of this rib upward and toward the spine, and thick pus was found. The knife was passed along the shaft of the needle and the opening dilated with blunt hemostatic forceps. Although no definite pocket of pus was found, the entire area was generally thickened and fibrosed. At a later date an operation revealed a small pocket which was opened and a considerable quantity of pus drained. This was packed and eventually a drainage tube was inserted. Still the patient did not effect a complete recovery until on April 3, 1941, he was reoperated upon and another pocket found under the 8th rib in the anterior axillary line, right. After drainage of this pocket the patient made a complete and uneventful recovery.

SUMMARY AND CONCLUSIONS

1. Three cases are reported in which a subphrenic abscess perforated the diaphragm and was evacuated through the bronchi.

2. In a collected series of 890 cases, Piquand found that this complication occurred in 12.6 per cent. In a later series of 3,608 cases Ochsner and DeBakey found that it occurred in 10.5 per cent.

3. The complication usually occurs late and is a result of delay in diagnosis or treatment. It may develop as early as the tenth day of the disease.

4. The patients may die suddenly by drowning in the pus; they may die in a short

time of acute bronchopneumonia, or may live for many years suffering from low grade sepsis and a chronic or intermittent productive cough.

5. In Steele's series of 48 cases of subphrenic abscess, the mortality was 50.8 per cent. Three of his 6 patients with bronchial fistula died, a mortality of 50 per cent. In a personal series of 75 cases of subphrenic abscess reported by Ochsner and DeBakey, the mortality in those with thoracic complications was 50 per cent as compared with 16.3 per cent in those without this complication. The 3 patients whose histories are the basis of the present report all recovered following operation.

6. Although an occasional patient will recover without operation, the institution of open drainage is urgently indicated.

REFERENCES

1. Cauderay, H. Contribution à l'étude des abcès sous-phréniques se terminant par vomique. Thèse de doct., Paris, 1902.
2. Ochsner, A., and DeBakey, M. Surg. Gyn. Obst., Internat. Abstr. Surg., 1938, 66: 426–438.
3. Piquand, G. Rev. chir., 1909, 39: 156.
4. Steele, J. D., Jr. Ann. Surg., 1937, 105: 496–506.

A COMBINED TIDAL IRRIGATOR AND CYSTOMETER FOR MANAGEMENT OF THE PARALYZED BLADDER

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THE therapeutic value of tidal irrigation of the urinary bladder had been proved by Munro (4 and 5) when he described his tidal irrigator. He also devised a separate cystometer (3) with which the bladder tone could be determined and changes followed. Simpler mechanical arrangements for tidal irrigations have been described since Munro's original contributions. One by Lawrie and Nathan and another by Bellis are efficient, simple, and easy to assemble. Stewart has emphasized that repeated cystometric studies are needed for the judicious use of any tidal irrigator, and he has described and used an apparatus in which a simple tidal irrigator and Munro cystometer are combined. He advocates cystometric studies not only before instituting tidal irrigation but also at frequent intervals later. With his apparatus it is necessary only to close off the siphon tube of the apparatus with a clamp and loosen a clamp to admit fluid into the manometer tube to record intravesical pressure.

The purpose of this communication is to describe a simplification of Stewart's combined tidal irrigator and cystometer that can be made up readily and used for the treatment of the paralyzed bladder under conditions of war without sacrifice of efficiency or control (Figures 1 and 2).

It is convenient to mount the apparatus on a board which protects the glass tubing from breakage and simplifies handling; however, it can be strapped to an intravenous stand and used without the board mounting. We have found a board arranged as in Figure 3 convenient. Rubber bands hold the apparatus to the board and make assembly and disassembly easy. This apparatus and method of assembly incorporate details described by Lawrie and Nathan, Bellis and Stewart.

Details of operation. It is necessary that the bladder and tubing connecting it with the apparatus be freed of air, otherwise air locks interfere with pressure readings and with smooth operation of tidal irrigation. The fluid from the drip delivery bulb, which has a side arm with an air vent valve attached, enters the arm of the Y tube and passes into the bladder through the rubber tubing connected to the indwelling catheter. The Y tube is placed at bladder level; with bed patients, the level of the top of the mattress suffices. As the bladder fills, the intravesical pressure increases and a fluid column appears in both the glass tubing and the siphon tube. When the column of fluid rises sufficiently to force fluid over the siphon tube loop, bladder emptying starts. When siphonage begins, fluid is drawn out of the glass tubing and air is sucked in through the hypodermic needle air vent valve but too slowly to interrupt the siphonage until the bladder is empty. When the bladder is completely empty the cycle begins again. It is always possible to tell at a glance if the catheter is properly in place and the apparatus is functioning, since respiratory excursions can be seen in the glass tubing. With a block between the system and the bladder, these disappear. If a Foley balloon catheter with two eyes is not available, as large a catheter as can be safely left in place is used, and it is desirable that it also have two eyes.[1] We prefer to fix such a catheter in place by the pipe cleaner method.[2] It may be important to keep the catheter and penis in the midline so that no pressure is exerted on the vas deferens or epididymis.

For irrigating solution we have used an autoclaved Ringer's solution or normal salt solution containing 0.3 per cent of sulfanilamide, 0.03 per cent of sulfapyridine, and 0.03 per cent of sulfathiazol. We have so far been unable to determine any absorption of the sulfonamides from the irrigating fluid into the blood stream. The working of the apparatus is explained to the patient and he aids in supervising it, watching so that the reservoir does not become empty, checking the rate of drip, and noting the respiratory excursions.

A practical way in which the apparatus can be demonstrated to the patient, as it is being set up as well as checked by the operator, is to attach a small toy rubber balloon to it and to watch several

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[1] If a two way catheter is used, irrigating fluid enters the bladder directly through the small lumen and the bladder is evacuated through the larger tube. There is therefore less trouble with sediment and the apparatus is further simplified in that the Y tube can be omitted. Two rubber tubes are connected with the catheter.

[2] The pipe cleaner method of tying catheters in place is now widely used. However, we have not been able to find the original reference. Our attention was called to the method by Lt.-Col. G. A. Winfield, R.C.A.M.C.

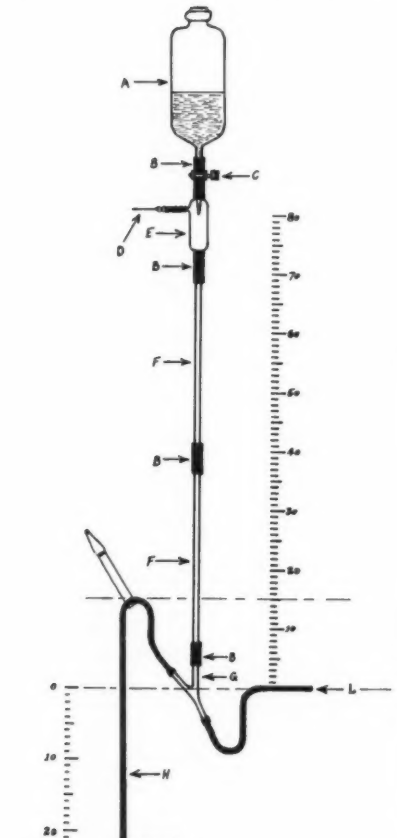

Fig. 1.

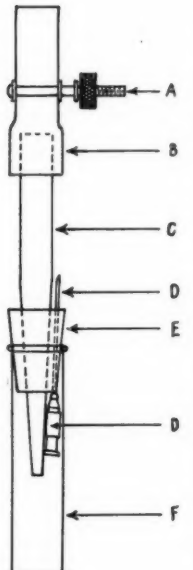

Fig. 2.

Fig. 1. Combined tidal irrigator and cystometer drawn to scale. *A*, Reservoir. *B*, Small sections of rubber tubing connecting the reservoir, drip delivery bulb, glass manometer tubes and Y tube. The size and adjustment of the rubber connections below the drip bulb should be such as to cause no local constrictions in the system. *C*, Metal screw clamp to control rate of drip. *D*, Air vent valve attached to side arm of drip delivery bulb by a rubber tube. A 22 gauge hypodermic or blood needle has a lumen that will allow the right amount of air to enter when siphonage starts and yet not break the siphon until the bladder is empty. A 20 gauge needle will also serve as a satisfactory air vent valve if the rate of drip is rapid. *E*, Drip delivery bulb with side arm. The inside diameter of the lower end should be approximately ⅝ of an inch or more. The lumen of the outlet must not be smaller than the lumen of the manometer tubes, otherwise air locks may form and interfere with operation. (See Figure 2 for improvised drip delivery bulb arrangements.) *F*, Manometer. Glass tubing 70 centimeters long with inside diameter approximately ⅝ of an inch. The glass tubing is divided into two pieces, each 35 centimeters long, to facilitate sterilization in a container of reasonable size. A centimeter rule placed along side of the manometer allows pressure readings to be taken at a glance. *G*, Y tube inside diameter approximately ⅝ of an inch. The apex of the V of the Y tube is set approximately at bladder level. The apparatus will function perfectly with it set at the level of the top of the mattress. *H*, Rubber siphon tube inside diameter approximately ⅝ of an inch. The height to which this is raised above the bladder level determines the pressure produced in the bladder before siphonage starts. The length of the tubing below the level of the bladder determines the maximum negative or suction pressure that can be exerted on the bladder. This is lessened somewhat by the air vent valve. In the illustration, the siphon tube loop is shown 15 centimeters above the bladder level and the length of the tube below the bladder level is 26 centimeters. The setting for the positive pressure must be determined for each bladder by cystometry. The negative pressure should perhaps not be allowed to exceed 26 centimeters in any case and may be lessened if an acutely inflamed bladder is to be irrigated. It is essential that the lower end of the siphon tube be kept above the fluid level in the container. Hence it is advisable that the receptacle *K* should have a rubber stopper *J* with two glass tubes through it, one to connect with the siphon tube and one *I* to serve as an air vent. For cystometry, the only adjustment necessary after the bladder has been emptied is to clamp off the siphon tube. *L*, Rubber tubing ⅝ of an inch inside diameter connecting single arm of the Y tube to catheter. This tubing is fastened to the mattress so as not to drag on catheter.

Fig. 2. Improvised drip tube delivery arrangement. If a drip delivery bulb with a side arm is not available, one can be made up easily from materials about the laboratory. One we have used satisfactorily was assembled as follows: A test tube, *F*, is cut off at the bottom. A rubber stopper, *E*, with a hole in it is inserted at the top. The glass tube of an eye dropper or a glass tube, *C*, pulled out to a tapered end, is passed through the cork to deliver the drops. A section of rubber tube, *B*, connects the improvised drip bulb with the container and the metal screw clamp, *A*, controls the rate of flow. A section of rubber tube, *G*, connects delivery tube with manometer. The air vent valve consists of a hypodermic or blood needle (22 or 20 gauge) inserted through stopper. Large T tube can be made into a drip delivery tube with needle air vent attached to its side arm.

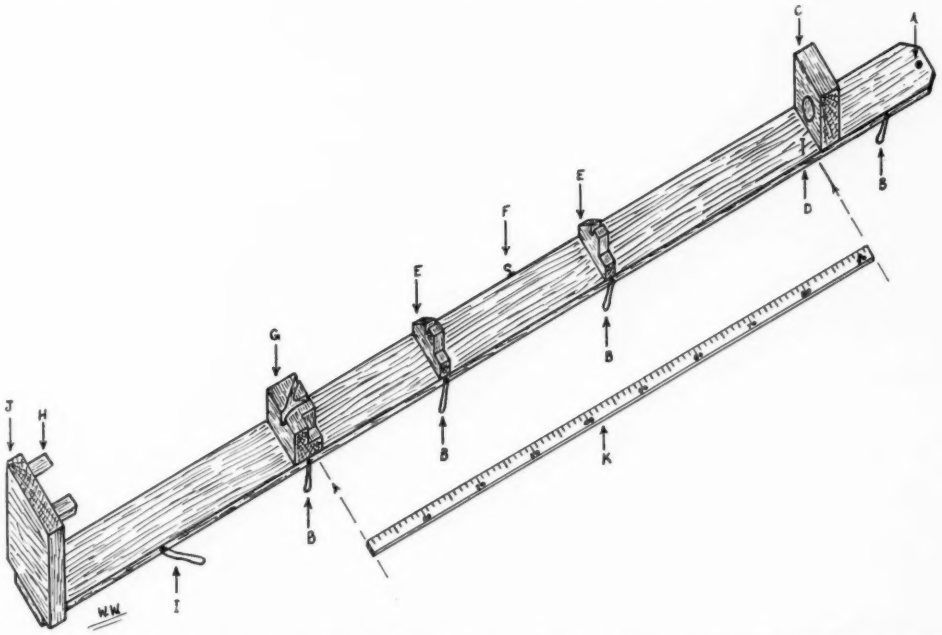

Fig. 3. *A*, Hole in board for suspension from an intravenous stand. *B*, Rubber bands for attachment to screws in sides of board to hold manometer in groove. *C*, Block with hole, through which projects lower end of reservoir. *D*, Nail from which hangs centimeter scale. *E*, Block with center and side cutouts for manometer tubing and centimeter scale. *F*, Hook for tape to adjust level of siphon tube. *G*, Block for Y tube and base of centimeter scale. *H*, Triangular blocks to hold receptacle on base of board *J*. *I*, Rubber band to secure receptacle. *J*, Base of board to hold receptacle. *K*, Centimeter scale which fits in grooves in Blocks *E* and *G*.

cycles of filling and emptying of the balloon (Fig. 4) before connecting the apparatus to the catheter. We make it a practice to sterilize such a balloon with the set each time tidal irrigation is instituted to check the apparatus and instruct the patient. It is also important to know the amount of suction exerted on the bladder and the period this suction is exerted before the siphon is broken. It can easily be measured by placing a manometer in the system (Fig. 5). The duration of the negative pressure is controlled in part by the caliber of the hypodermic needle air vent valve. The absolute amount of the negative pressure is determined by the length of siphon tubing below the bladder level. However, this is modified by the size of the air vent valve.

The desired setting of the siphon loop is determined after cystometry. Its height must be just below the level of the intravesical pressure produced by the amount of fluid which the bladder should contain before being emptied. For example, if it is estimated that the bladder should not contain more than 250 cubic centimeters, the siphon level is set just below the pressure produced by this amount of fluid in the bladder. The bladder will then automatically empty every time this amount enters it. In practice, in determining the number of times per 24 hours the bladder is to be emptied, we have ignored the normal secretion of urine and figured only the number of emptyings which would be produced by the irrigating fluid dropping at a certain rate. For example, if the bladder is to be emptied when it contains 250 cubic centimeters of fluid and this emptying is to be done twelve times in 24 hours, the total amount of irrigating solution necessary for this period would be 3000 cubic centimeters. The rate of delivery would be 125 cubic centimeters an hour, a little over 2 cubic centimeters per minute or about 50 drops per minute. The fluid should be allowed to drip more rapidly causing frequent irrigations if infection or much sediment is present; if not, less frequent irrigations suffice. The only contraindication to frequent emptying is the volume of irrigating solution used and the time required to keep the reservoir full.

Fig. 4a.

Fig. 4b.

Fig. 4. a, Combined tidal irrigator and cystometer with rubber balloon attached. Balloon is distended with fluid from reservoir. Positive pressure of 28 centimeters of water can be seen registered in glass manometer. b, Same as a except balloon is empty and no positive pressure is registered in manometer. Fluid can be seen in siphon tube entering receptacle. The rubber balloon is boiled up with the apparatus. When tidal irrigation is to be used on a patient for the first time and before the apparatus is put into operation, the patient is shown how it works with the artificial bladder.

Fig. 5.

Fig. 5. A simple water manometer connected up as shown was used to prove that the suction pressure exerted on the bladder after it was emptied and before air broke the siphon could be altered by raising or lowering the waste container. The balloon is empty and the negative or suction pressure is demonstrated. Note that the negative pressure in the manometer is slightly less than the length of siphon tubing below the bladder level.

For cystometry with this apparatus, it is only necessary to close off the siphon tube after the bladder has been emptied. Fluid is then allowed to enter the bladder at the rate of about 120 drops per minute, and pressure readings are taken at 50 cubic centimeter intervals. The patient's first desire to void, if present, is recorded; time of discomfort and distress is also noted. Bladder contractions are charted when they occur. Two recordings are given, one showing the period of areflexia (recording 1) after a cervical spinal cord injury and one (recording 2) illustrating the spinal reflex bladder. These figures can be used to chart curves if graph paper or standard cystometrogram charts are available.

RECORDING 1. ATONIC BLADDER

Fluid in bladder—c.c.	Pressure
0	0
50	2
100	2.5
150	3
200	4
250	5
300	6
350	7
400	8
450	8.5
500	9
550	9.5
600	10
650	11
700	12

No sensation noted by patient. Capacity over 700 cubic centimeters. No reflex contractions observed.

RECORDING 2. CYSTOMETROGRAM. SPINAL REFLEX BLADDER

Fluid in bladder—c.c.	Pressure
0	0
50	7
100	8
150	9
200	10
250	10 –67*
300	12†–90*
350	15 –90*
400	17
450	22
500	17 –90*
550	17‡
600	47¶
650	34

*Reflex contraction.
†Uncomfortable.
‡Marked discomfort.
¶Desire to void.

Cystometrogram shows a bladder with normal tone, some sensation, and reflex contractions.

Fig. 6. Combined tidal irrigator and cystometer attached to indwelling catheter of patient. Y tube is at bladder level. Note pipe cleaner method of retaining catheter in place and the catheter strapped to the patient's leg with adhesive and tube pinned to mattress.

SUMMARY

A simple combined tidal irrigator and cystometer for the urinary bladder is described which may be assembled under adverse conditions and which in our hands has advantage over other irrigators we have used. It allows for alternately filling and emptying the bladder automatically to provide tidal irrigation and permits cystometry with only one adjustment. True tidal irrigation must be constantly maintained at optimum rates and pressures to be efficacious and this requires intelligent supervision. We agree with Lawrie and Nathan that the chief applications of tidal drainage are:

"1. To prevent the occurrence of infection; it is certainly a life saving measure in 'neurological bladders' as Munro's cases show.

"2. To control the infection of primary cystitis, after oral therapy has failed.

"3. To increase the capacity of a contracted fibrotic bladder by progressively increasing the height of the siphon-tube over a period of weeks.

"4. It may be used wherever an indwelling catheter or repeated catheterization is indicated, with the advantages that antiseptic solution is almost continuously in contact with the bladder walls, and that it will not allow the progressive contracture of the bladder which occurs with an indwelling catheter draining away continuously."

We have not used tidal irrigation when gonococcal urethritis was present but have not hesitated to start it when urethritis due to an indwelling catheter was a complication at the time of admission. Normal salt or Ringer's solution with dissolved sulfonamides has been used as irrigants with satisfactory results.

Dr. Emerson Smith, urologist in chief of the Royal Victoria Hospital, points out that the weakness in tidal irrigation is the indwelling catheter. There is the danger of ulceration of the urethra and spread of infection to the periurethral tissue, to the prostate and epididymis, and to the blood stream. He points out the importance of avoiding traction on the catheter which might traumatize the urethra and advocates, as others using indwelling catheters have done, that the catheter be changed and the urethra irrigated every 3 to 5 days.

To avoid possible trauma we have strapped the catheter to the patient's thigh and pinned the tube connecting the apparatus to the catheter to the mattress. Since these precautions have been observed we have had no complications from indwelling catheters (Figure 6).

We prefer tidal irrigation controlled by cystometry and intelligently supervised to other methods of treatment of the recently paralyzed bladder. In patients in whom it has been proved that voluntary control of bladder function will not return and adjustment to reflex emptying is unsatisfactory, we then consider suprapubic drainage.

REFERENCES

1. Bellis, C. J. Surgery, 1940, 8: 791–797.
2. Lawrie, R. S., and Nathan, P. W. Lancet, Lond., 1939, 2: 1072.
3. Munro, D. N. England J. M., 1936, 214: 617.
4. Idem. Am. J. Surg., 1937, 38: 120–136.
5. Munro, D., and Hahn, J. N. England J. M., 1935, 212: 229.
6. Stewart, Oscar W. Lancet, Lond., 1942, pp. 287–289.

HYDATIDOSIS OF THE LUNG

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ON March 23, 1939, I operated upon a 39 year old patient whose clinical examination revealed the existence of two hydatid cysts; a large one in the left lung and another smaller one in the right lung (Figs. 1 and 2).

After a preliminary pneumothorax, we performed an anterior thoracotomy under a local anesthetic, removed 12 centimeters of the 4th rib and evacuated a hydatid situated on the superior lobe of the left lung. The cyst was unilocular and had no daughter vesicles. In accordance with Posadas' method, the incision in the lung was sutured without drainage. Previously a thorough and careful cleansing of the adventitious pouch had been carried out. The incision in the thoracic wall also was closed without drainage.

The wound healed uneventfully and *per primam*. Seven days after the operation x-ray films (Figs. 3 and 4) showed that the pneumothorax had disappeared and that the adventitia had shaped itself into a cavity containing a small amount of fluid. The films also showed the unoperated upon cyst in the right lung. The patient was discharged from the hospital 18 days after his operation and was advised to return for a further operation on the other cyst.

A tomograph, taken 6 weeks later (Fig. 5), showed the cyst in the right lung and the adventitious cavity in the left lung. The fluid observed in previous x-ray films had disappeared altogether.

The patient was readmitted to the hospital a little over a year after his first operation; his lung condition is shown in Figure 6. The cyst in the right lung remained unchanged, and on the left side the residual cavity of the operated upon cyst was greatly reduced in size. However, within the well defined though slightly misty limits of this cavity, there was recognized two or three sphere-shaped shadows, the nature of which was unknown. We must confess that, at the time no special importance was paid to these shadows; our attention was wholly concentrated on the cyst in the opposite lung.

The treatment of the cyst in the right lung was carried out a few days later by my colleague, Dr. Ivanissevich. With the object of reaching the cyst without having to open the pleura, he resorted to the extrapleural pleuropexis method

Director of the Institute of Surgery, University of Buenos Aires.

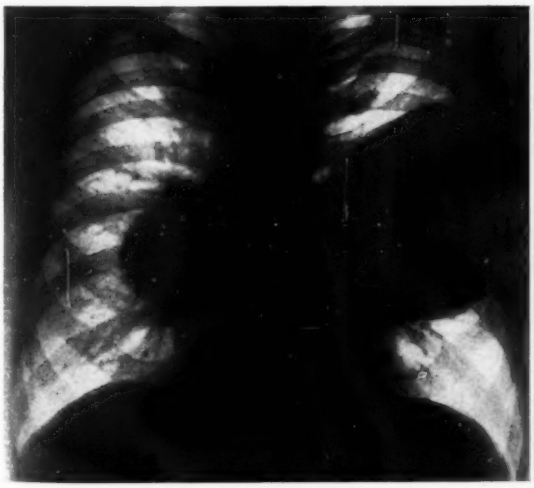

Fig. 1. Showing a large hydatid cyst in the left lung and a smaller one in the right, March 3, 1939.

Fig. 2. Lateral view. The two shadows are partly superimposed, March 3, 1939.

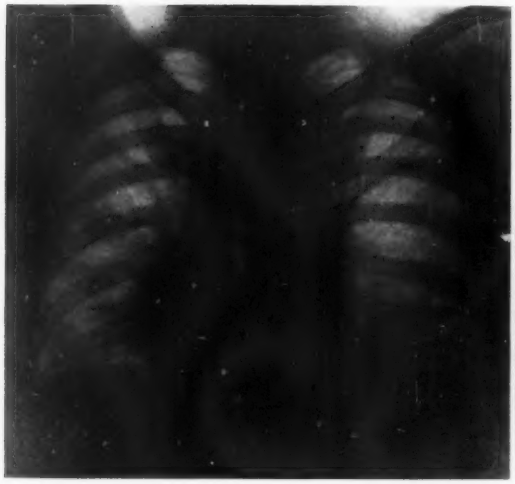

Fig. 3. After the first operation. In the left lung, the residual cavity of the cyst shows the presence of a small amount of fluid. In the opposite lung is seen the shadow of the other cyst, March 30, 1939.

Fig. 4. Lateral x-ray after the first operation, April 10, 1939.

(also called the Lamas-Mondino procedure). Unfortunately, a severe inflammatory reaction followed, and abundant serous fluid made its appearance in the pleural cavity (Fig. 7). An x-ray film showed, apart from the fluid in the right pleural cavity, the residual cavity still existing in the left lung and clearly containing 4 or 5 small sphere-shaped shadows, two of them seemingly larger than those seen previously. Later an x-ray film (Fig. 8) showed a total opacity of the right side due to the pleural thickening which followed the serous pleuritis. This opacity hid the results of the uneventful operation on the cyst (incision, evacuation and drainage) which had been performed 2 months previously. The residual cavity in the left lung was still visible, though the round shadows therein had altered their position slightly. Figures 9, 10, 11, 12, 13, and 14 illustrate the evolution and growth of the sphere-shaped shadows in the left lung. These films reproduce only the affected zone of the successive original films. The patient returned to his residence in the country after the skin wound had healed completely and was advised to visit us periodically.

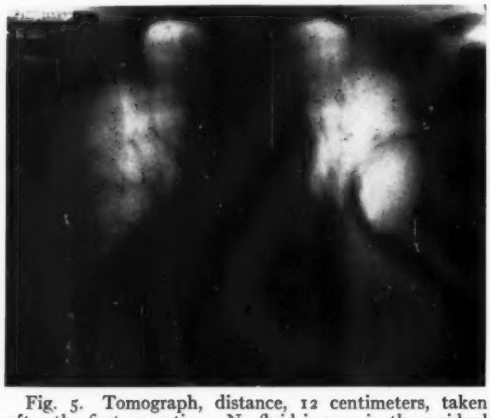

Fig. 5. Tomograph, distance, 12 centimeters, taken after the first operation. No fluid is seen in the residual cavity, May 24, 1939.

Thirty months after the first operation and 17 after the discovery of the rounded-shaped shadows inside the residual cavity of the left lung, the patient was readmitted to the hospital and x-ray films were taken (Figs. 15 and 16). The pleural opacity in the right hemithorax had cleared considerably; in the left one, the residual cavity had disappeared and in its place was the typical image of a hydatid cyst. Had we not been aware of the former presence of a cyst in that exact place and of the evolution of its residual cavity, we should have been inclined to make a diagnosis of primary hydatid cyst of the lung. Instead, our 17 months' careful observation of the evolution of the cavity allowed us to state that it was a *hydatid recurrence inside the residual cavity of the original cyst.* The general condition of the patient was excellent

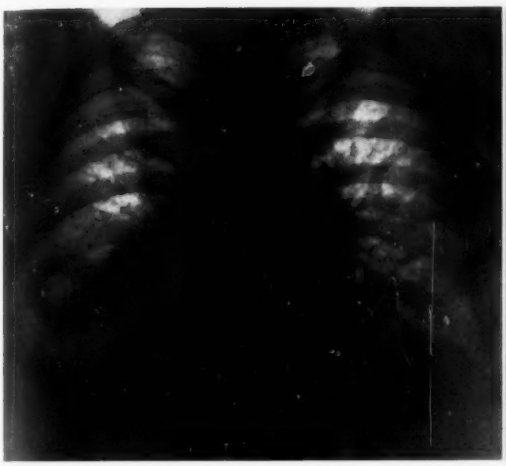

Fig. 6. April 9, 1940. The shadow of the cyst in the right lung and 3 small ones in the residual cavity in the left lung are visible.

Fig. 7. Treatment has been started on the cyst of the right lung; notice the large amount of the fluid in the pleural cavity on that side. The residual cavity of the left lung is shown to have 5 small shadows in the roentgenogram, May 10, 1940.

and there were no subjective symptoms of any kind. Until told he should have to undergo a third operation, he thought that our interest was confined to the postoperative results of the earlier operations.

In considering this case, two hypotheses are suggested. First, a new hydatid cyst, developing next to the residual cavity of the previously operated upon cyst, might have grown to the extent of occupying the very same site where the cavity was formerly situated. This line of thought would signify that the new cyst was already present at the time that the first operation had been performed though it was of so small a size that it had escaped detection.

There are two objections to this hypothesis: (a) the preliminary pneumothorax—through the total collapse of the lung—would have revealed any other abnormality; (b) had the abnormal element been so small that even the collapse of the lung were not enough to reveal its existence, the palpation of the organ during the operation would have done so. In the case of the left lung we *felt only one tumor*, and only after a year did we suspect that *something else* was developing in the same place. Finally, since the growth of hydatid cysts is a slow process and as we had observed the sphere-shaped shadows grow, so to speak, before our very eyes inside the well defined contour of the postoperative residual cavity, these observations were also opposed to the diagnosis of a new cyst.

The second hypothesis—infection of the adventitious membrane or of the fluid contained within it—is still less likely to hold good. The fluid had disappeared completely without giving rise to either subjective or objective signs and a year later we had seen its place taken by the newly formed shadows. It was, therefore, highly improbable that fluid had appeared once again and become infected. As for an infection of the

Fig. 8. Total opacity of the right hemithorax. Four small shadows in the residual cavity of the left lung, July 15, 1940.

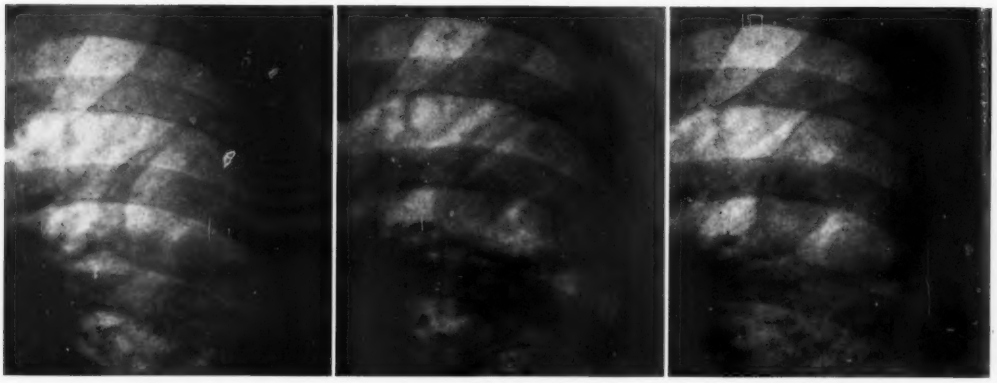

Fig. 9. Fig. 10. Fig. 11.

Fig. 9. Enlargement of roentgenogram, Figure 6.
Fig. 10. Roentgenogram of May 3, 1940.
Fig. 11. Enlargement of roentgenogram, Figure 7, May 10, 1940.

adventitious membrane, this would have caused both local and focal reactions, together with repercussions of a varied degree on the general condition of the patient; it must be remembered, however, that the patient's condition had been excellent throughout the period of observation.

We have already stated that no daughter vesicles were found inside the cyst in the course of the first operation. Of this we can be certain because it is our practice always to carry out a thorough search and cleansing of the inner aspect of the cavity by means of the *speculum-procedure*, that is by the use of a bivalve vaginal speculum. This instrument and the careful cleansing of the adventitia allow speedier healing, whether the wound is sutured without drainage, as in this case, or the cyst cavity is marsupialized.

There is no doubt that in this instance, and in spite of the thorough cleansing of the adventitia, some fertile scolices must have remained and become grafted in that closed pouch which lacked both a communication with the bronchial tree and outward drainage. This hypothesis is not affected by the presence of the postoperative fluid spotted in the residual cavity; this fluid must have been aseptic blood serum which was reabsorbed later on, thus allowing the scolices to develop inside the cavity. The hydatid vesicles—resulting from the scolices—were seen to grow under roentgenographic observation, and once these vesicles have attained sufficient size to occupy the surface of the residual cavity, their joint shadows appeared as a new hydatid cyst in this locality.

Fig. 12. Fig. 13 Fig. 14.

Fig. 12. Roentgenogram of May 27, 1940.
Fig. 13. Roentgenogram of June 12, 1940.
Fig. 14. Enlargement of roentgenogram in Figure 8, July 15, 1940.

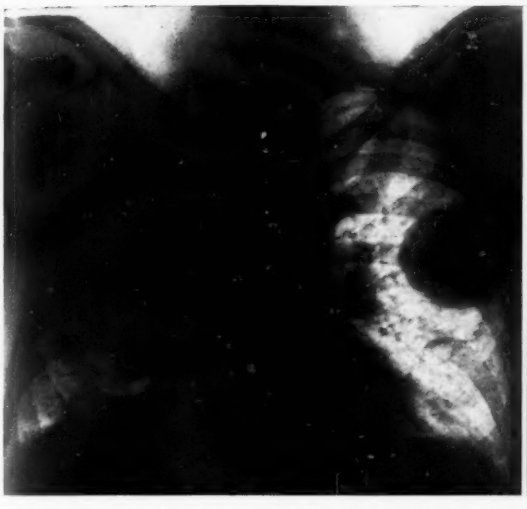

Fig. 15. September 8, 1941. The residual cavity has disappeared from the left lung and its place has been taken by an uneven shadow resembling that of a hydatid cyst.

Fig. 16. A lateral x-ray view shows that the cyst's shadow is not even. The contour of the residual cavity is no longer visible, September 8, 1941.

This explanation was confirmed at operation, for we found, not one hydatid with a mother germinative membrane containing daughter vesicles floating in the fluid but several isolated hydatids, in intimate contact with the adventitia.

The patient was again submitted to a preliminary pneumothorax which caused a partial collapse of the lung. We found that the lung had become adherent to the thoracic wall in the axillary region, a little behind the anterior thoracotomy, thus paving a road which allowed us to reach the cyst without opening the pleural space. This adherent zone corresponded exactly to the lung adhesion found at the first operation.

Under cyclopropane anesthesia, we resected a few centimeters of the posterior segment of the 4th rib—already affected by the first operation—and we came upon the zone of adhesions. After crystal clean fluid had been removed by means of an exploratory puncture, and, without having to cross any lung tissue, we made a superficial incision in the same area which opened a cavity the size of an orange. From this cavity some seven or eight hydatid vesicles were extracted, apart from those which were released by the incision and carried away by the fluid which came from the cavity while the first incision was being enlarged.

The vesicles shown in Figure 17 were removed from the adventitious pouch with the aid of an ordinary soup spoon; this instrument we have always found most useful for the purpose of extracting any daughter cysts. The speculum procedure allowed us to remove the remains of other daughter vesicles, wipe out the remaining fluid with gauze swabs and finally to carry out a thorough cleansing of the cavity. In spite of the existing adhesions, we sutured the walls of the cyst to the edges of the incision in the thoracic soft parts, without including the skin. A rubber drainage tube, supported by gauze, and a few skin sutures to decrease the size of the incision completed the operation. Figure 18 shows the patient's left hemithorax after the third operation.

Some years previously, I had the chance of operating upon a woman patient who had a hydatid cyst of the right lung and another one of the liver. After insufflation of the right pleura (preliminary pneumothorax) and under a local anesthetic, I carried out a posterior thoracotomy through the 6th rib. A hydatid cyst of the inferior lobe was found—the contents were of a hyaline nature with no daughter vesicles—and it was treated according to Posadas' method (evacuation of the parasite and suture without drainage). After operation, x-ray films showed the appearance of fluid in the adventitious cavity. A year later, the liver cyst was treated with the same technique. But having found a suspicious shadow at the former level of the lung cyst operated upon, and under a general anesthetic with cyclopropane, we performed a new thoracotomy in order to

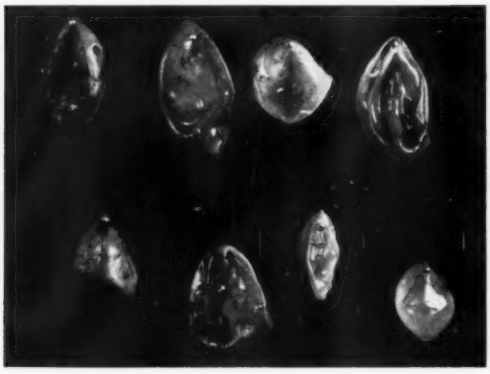

Fig. 17. Eight hydatid vesicles extracted during the third operation from the former residual cavity, November 5, 1941.

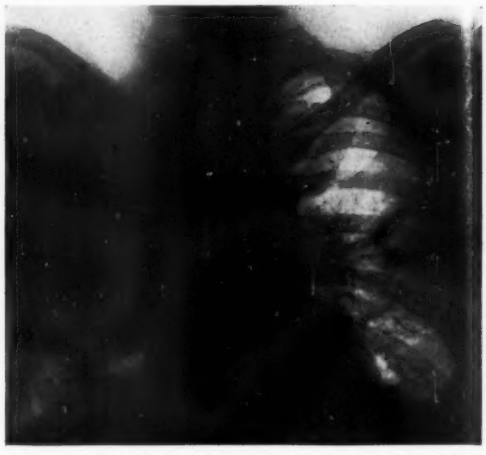

Fig. 18. The adventitious pouch in left lung after third operation—incision and drainage. It shows some fluid.

reach the residual cavity of the first operation. An exploratory puncture drew out light colored fluid, so we incised the cyst and more fluid came out, together with four live hydatid vesicles of diameters from 1 to 2 centimeters. The speculum procedure revealed the absence of a mother germinative membrane. The operation was completed with marsupialization and drainage.

This second operation led us to believe that we were faced with a hydatid recurrence through some scolex which remained adherent to the walls of the cyst after the first intervention.

The live—and therefore fertile—hydatid elements (scolex, hydatid vesicles) are capable of becoming grafted on human tissues, and without having to undergo the stage of taenia echinococcus, they can give rise to a hydatid cyst. The experimental demonstration of this fact has been made by Dévé, and clinical observations have shown that hydatid cysts have grown on surgical scars after operations on cysts of the liver, lung, and other locations.

Recurrences of hydatid cysts of the lung are indeed very rare, and this has led some authors to state that these hydatids are not fertile. This statement is not correct, and we have personally been able to prove that these cysts are without any doubt capable of reproducing new ones. Besides, observations on postoperative hydatid grafts have been published; most of them are of grafts on the wound, only a few in the pleural cavity. Therefore, the possibility of grafts cannot be discussed.

So far we have come across no published cases of grafts in the residual cavity lined by the adventitious membrane. We believe that the 2 cases reported here are the first ever published on this type of recurrence; this is specially true of the first one, in which, to our minds the evidence is as conclusive as that of any laboratory test.

There might be some question as to whether the relapse in our first patient might not have been due to other disease. From our point of view there could have been no other diagnosis than the one we made. The following facts support the belief that some scolices had been left behind at the first operation and had undergone vesicular transformation: disappearance of the postoperative fluid in the residual cavity, the presence of sphere-shaped shadows in that cavity, growth of these shadows to the point of filling the entire cavity, and an uneven shadow which took the place of the former shadows in the last stages before the second operation. Then again, the first operation had shown that there were no daughter vesicles present, and, besides, as we intended suturing the adventitia without drainage we used the speculum procedure and carefully cleansed the cavity. Therefore, there can be no other possible explanation than that of progressive development of a few scolices.

The word "graft" used previously requires further explanation though it cannot be stated as a positive fact that scolices have attached themselves to given points of the adventitious wall. At the same time, the possibility of its happening cannot be denied. Some of the x-ray films have conveyed to us the impression that one or more vesicles were free inside the cavity and had apparently shifted their position a few times. Besides, we believe that the nutrition of the scolices

takes place whether attached or not, so their maximum growth depends only on the capacity of the containing cavity in which they develop. Later these vesicles would grow in the same way as those which have been carried by the bloodstream (embolism) and become grafted, but it is obvious that they would never attain a very large size for the reason that these patients usually continue under observation for a certain time after the operation.

Does the method of suture without drainage favor this type of hydatid recurrence? To my mind it does. Moreover, as the postoperative evolution of this method hardly differs from that of marsupialization, its systematic use is far from justified. But if, for given reasons, we have to resort to Posadas' method, following the evacuation of the parasite, the interior of the cavity should be thoroughly washed and rubbed with gauze swabs soaked in ether. Under these circumstances the ether will afford a certain degree of guarantee, if not of killing all the parasites present, at least of greatly diminishing their vitality.

HAZARDS OF FIRE AND EXPLOSION OF ANESTHETIC AGENTS

IV. In the Presence of Suction and Vaporizing Machines

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IN this report we devote our attention entirely to the hazard created by the operation of suction and vaporizing machines in the presence of a combustible anesthetic agent. This problem deserves special emphasis because these machines have set off more combustions than any other single type of igniting agent, exceeding by far static electricity, the cautery, or diathermy. The oft quoted estimate (1) of a hundred ether accidents a year in this country would be found too low if all the cases were known in which the ignition was caused by a suction or vaporizing machine. Unfortunately, this type of anesthetic fire or explosion has rarely been reported; therefore, our statistics show the incidence of this type to be less than that of the more frequently published static-ignited combustions, a relative position which we do not believe is in accord with the true incidence.

We have collected 58 cases[1] ignited by an electrical spark produced by the use of a suction and vaporizing machine, either or both. Few of these have ever been reported officially in a medical journal or before a scientific organization, although some have caused serious injuries. In fact, all the manufacturers of the various models (4) deny any knowledge of a case involving their particular machines. Oddly enough, a large number of them have gone through the effort and expense of making some of their models explosion-proof. It is curious to note how complacently this type of anesthetic combustion has been accepted for very many years, in striking contrast to the hysteria usually aroused by the more publicized static explosions. The probable reasons for this difference of attitude are that in the case of machine sparking, the cause has always been obvious and one's conscience is disturbed by the failure to have taken the known preventive measures, whereas in the instances of static explosions the causes have been considered obscure and the means of prophylaxis difficult and debatable. Furthermore, electrical machine explosions have practically always involved the familiar anesthetic, ether, whereas static combustions have often involved newer and unfamiliar agents, such as ethylene and cyclopropane.

The descriptions of cases ignited by suction and vaporizing apparatus are monotonously alike and simple. Open drop or insufflation ether anesthesia is started or in progress when suddenly there is a

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This is the fourth in a series of reports by the Committee on Anesthetic Fires and Explosions, B. A. Greene, M.D., chairman, a subcommittee of the Research Committee of the American Society of Anesthetists, Inc.

[1]We acknowledge the great co-operation of the members of the Society who personally reported to us 46 of the 58 cases in this category.

flash, a trail of fire into the ether bottle and a burst of flaming ether all through the room. It is the pattern for most accidents of this type. Frequently the machine has been started or stopped just before the flash but just as often there has been no prior manipulation of the switch.

In 57 of the 58 cases, the ignited anesthetic mixture has been ether-air. The other incident involved cyclopropane-air. No one was injured in 47 of the cases (46 ether-air and 1 cyclopropane-air). In all 58 cases only 2 patients were affected, one was slightly and the second seriously burned about the head; 2 surgeons, 1 nurse, and 4 anesthetists were seriously burned, 1 anesthetist and 5 surgeons slightly injured. This record is a striking tribute, not to the safety of ether, but to the retarding influence of air (approximately 79 per cent nitrogen—21 per cent oxygen) on the force and propagation of the pressure and flame waves of ether combustions with air as compared with ether-oxygen and ether-nitrous oxide-oxygen mixtures. The long period of toleration of this hazard has been due largely to this factor of relative harmlessness which is associated with the combustion of any anesthetic mixed with air.

This type of anesthetic fire or explosion is completely preventable today because of the progress in design and construction of suction and vaporizing machines. Inferior apparatus presents 5 possible sources of electrical sparks or arcs capable of igniting any combustible anesthetic mixture. These are: (1) arcs produced at the make or break of the electrical circuit by the ordinary open switch; (2) sparks produced by the revolving armature of the motor; (3) sparks produced by the electrical current which may be *induced* in the metal shell of the cabinet by the operation of the motor; (4) sparks produced by static electricity caused by the friction of parts of the apparatus within itself or against external objects. The induced electricity in item 3 or the static charge may spark in jumping the air gap to a grounded object or person or to an ungrounded object with a large electrical capacity; (5) arcs produced by the make and, more often, the break of contact of the plug with the wall socket. This may be accidental as when the conducting cable is kicked, stepped on or drawn too taut.

Modern design and construction of suction and vaporizing apparatus and of electrical fixtures for use in operating rooms have provided the sure protection from this source of ignition which anesthetists and surgeons must demand for themselves and their patients in the hazardous circumstance of an anesthetic-laden room unavoidably produced by insufflation anesthesia.

1. The open arcing switches are replaced by mercury switches. The opening and closing of the circuit is secured by the tilting of mercury in a glass tube in which are sealed the contact ends of the circuit.

2. The motor is sealed so that no contact is possible between the internal parts of the motor and the external atmosphere.

3 and 4. The metal shell or cabinet is freed of *induced* and *static* electricity by grounding. Grounding is automatic when the conducting cable of the machine is furnished with a three prong plug which fits into a triple contact socket containing a ground line built into the socket and wall during the installation of the electrical fixtures. If the wall socket is the conventional double contact type, made to receive only a two prong plug, then the metal cabinet must be grounded by a dangle wire attached at one end to ground and at the other end to an unpainted part of the cabinet or to the third and unused prong of the three prong plug. The three prong plug may then be fitted to the double contact socket by means of a suitable adaptor which provides a site for the connection of a ground wire to the "ground prong" of the three prong plug.

5. Arcing at the wall socket plug contact is to be avoided during the danger period by making the connection before the anesthesia is started and by not breaking the connection until the room is ventilated free of the combustible vapors or gases. Furthermore, to prevent accidental breaking of the plug socket contact during the danger period, the plug socket connection should be of the locking type (6). The plug cannot be simply pulled out because it is inserted into the wall socket and locked there by partial turn or twist. Also, the wall outlet should be situated 4 or 5 feet above the floor to avoid the floor level at which the anesthetic most often used in vaporizing machines, namely, ether, tends to accumulate because of its heavy density.

These safety devices have long been available to hospital authorities. Ignorance of the hazards and lack of demand by anesthetists and surgeons have permitted the growth of the present dangerous situation wherein most insufflation anesthesias today are given in the presence of serious and obvious and preventable sources of ignition.

There is another method of securing a completely safe suction and vaporization and that is by the use of wall outlets connected by pipe lines to a remote, centrally located source of suction and pressure. This arrangement is ideal in many respects; however, it is suitable only for installation in the process of construction or renovation.

Many anesthetists have reported, after an accident or two, the adoption of inadequate methods of prevention such as: buying another manufacturer's apparatus not of explosionproof type, or avoiding machines which suck ether into the compartment containing the motor, or discontinuing the practice of refilling the ether bottle while the motor is running. We know, however, that nothing short of the complete scheme of safeguards described here is entirely safe in the light of our present information.

The additional cost of such safety features as we have described is not prohibitive even for the small hospital. The extra expense is a permanent investment to be regarded as insurance against costlier injuries, property damage and malpractice claims. A plaintiff's lawyer would have a field day with a damage suit resulting from a fire or explosion ignited by a suction or vaporizing machine.

The approval of the Underwriters' Laboratories which is always sought in practically every other type of electrical apparatus, should always be demanded by hospitals and practitioners seeking to buy suction and vaporizing machines for use with anesthetic agents. There are many safe and approved models available through most of the manufacturers. This recommendation is in line with the authoritative editorial statement of Dr. W. E. List, "In new constructions, the installation of explosionproof electrical equipment should be mandatory, and, whenever possible, hazardous fixtures should be replaced in old constructions."

We believe that it is the duty of the anesthetist to inspect the safeguards necessary for safe insufflation anesthesia and to insist on maintaining the very high standards of safety expected of all types of anesthesia. It is lopsided wisdom to follow strict antistatic precautions in the major operating rooms, while, in the "tonsil" room, one continues to expose a roomful of ether to a dangerous suction and pressure machine. With the few and simple safety measures described in this paper, we can prevent all anesthetic ignitions by this type of electrical apparatus and so eliminate about 25 per cent of all anesthetic explosions and fires. Indeed, the hazard and its prophylaxis have been officially recognized to the extent that a Canadian law was declared in effect on May 1, 1940, making it mandatory to use only those models of suction and vaporizing apparatus in the operating room which meet the standards of fireproofing and explosionproofing specified by the Ontario Hydroelectric Power Commission (4). These standards have been satisfied by the better types of machine offered by leading American manufacturers since 1932.

SUMMARY AND CONCLUSION

Fifty-eight cases of anesthetic explosions and fires ignited by an electrical spark originating in suction and vaporizing apparatus are reported.

The hazard has been analyzed and the five zones likely to contain sparking or arcing have been described.

The safeguards against these five dangerous zones have been described in detail.

We have reached the conclusion that this type of anesthetic fire and explosion is entirely preventable with the knowledge and apparatus available today.

REFERENCES

1. Editorial. J. Am. M. Ass., 1929, 92: 476.
2. Foreign news letter. J. Am. M. Ass., 1924, 82: 1794.
3. List, W. E. Editorial. Hospital, 1939, 13: 73.
4. Ontario Hydroelectric Power Commission. Personal communication.
5. Proc. Meet. Am. Soc. Anes., Inc., 1938.
6. Underwriters' Laboratories, Inc. List of inspected electrical equipment. May, 1940, Pp. 442–444.

SLIDING HERNIA

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SEVERAL years ago Bevan introduced his paper on sliding hernia with the statement that during an operation upon a hernia of this type, he questioned his internes and assistants as to the anatomy and pathogenesis of sliding hernia and found that they had very little knowledge of the subject. He considered this a reason for his presentation of the matter. By virtue of his paper and the other excellent discussions which have appeared in recent years, unfamiliarity with the problem of sliding hernia no longer prevails. It is our impression, however, that the question of treatment, with particular reference to the disposition of the sac, has been made unnecessarily difficult. The purpose of this presentation is to describe again the anatomical relations in sliding hernias and to advocate a return to the older and simpler method of dealing with the sac and its contents.

Sliding hernia, as the name implies, is a hernia in which some portion of retroperitoneal viscus is drawn down into the sac of an inguinal hernia. Two types have been described (Fig. 1). The more common variety is designated the parasaccular or partially extrasaccular variety. This type corresponds with that described by Moschcowitz as a hernia produced by a "pulling mechanism." Because of the increasing size of an indirect hernial sac, traction is made on the parietal peritoneum until some portion of retroperitoneal viscus, usually cecum or descending colon, is drawn into the sac. Under these circumstances, there is almost invariably a free fold of peritoneum comprising the anterior wall of the sac. The posterior wall, however, is made up of bowel with its partial peritoneal investment.

The second type, which is statistically much less common, is the extrasaccular or sacless hernia. This corresponds to Moschcowitz's hernia by "pushing" mechanism. In hernias of this type, the viscus together with its peritoneal covering is pushed directly through the hernial orifice. It must be obvious that such herniation cannot occur in indirect hernias if the saccular explanation for the genesis of oblique inguinal hernia is to be accepted. It is possible, however, for such hernias to present through direct hernial orifices, and herniation of the bladder is not infrequent in this type of hernia.

The literature on the subject correctly emphasizes the possibilities of severe hemorrhage and of potential devitalization of the contained segment of large intestine if the sliding nature of the hernia is not recognized and if misguided attempts are made to dissect the bowel from the sac under the misconception that it is fixed by inflammatory adhesion. Such accidents have occurred. In order to obviate this danger, various methods of dealing with the bowel and the sac have been devised. These fall into two main categories. The one most often recommended consists of attempts to peritonize the posterior wall of the bowel or to

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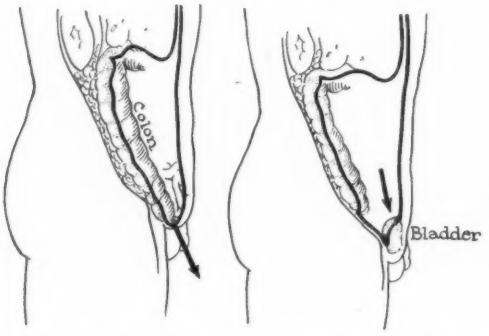

Fig. 1. Mechanism of sliding hernia. a, left, Posteriorly placed structure is drawn into sac by pulling mechanism. b, Pushing mechanism which can affect only anteriorly placed structures such as bladder.

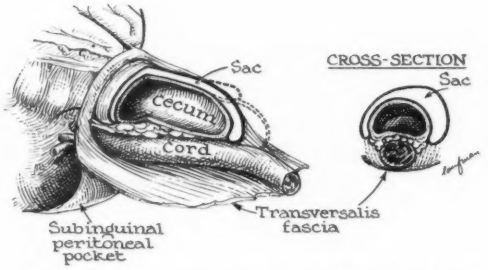

Fig. 2. Position of sac and bowel in sliding hernia with relation to spermatic cord and posterior wall of inguinal canal.

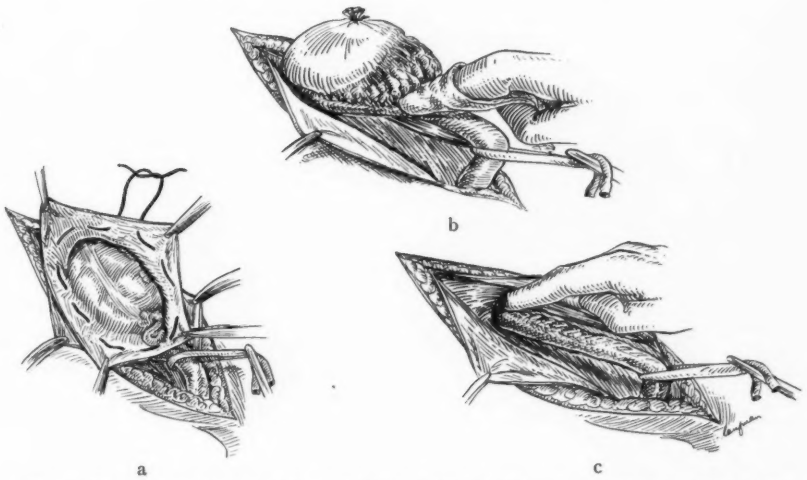

Fig. 3. Disposition of sac and its contents in sliding hernia. a, Pursestring closure of sac. b, Dissection of sac and bowel from cord structures. c, Reduction of sac through internal ring.

create a mesentery from the peritoneal tissue of the sac. Such methods have been described by Hotchkiss, Walton, Bevan, and several earlier authors. The second method, originally propounded by Moschcowitz, and more recently advised by Graham, consists of a free laparotomy incision with reduction of the colon from above and fixation to the posterior abdominal wall.

These methods are based upon the fear of injury to the mesenteric vessels coursing beneath the bowel which occupies the hernial sac. The illustrations which usually accompany such descriptions give the impression that these vessels retain their normal relationship to the areolar tissue over the iliopsoas muscles. This is an obvious fallacy. Once a viscus has entered a hernial sac, it has, perforce, left the abdominal cavity. As it emerges through the internal ring, it comes to lie upon the transversalis fascia together with the spermatic cord, as is the case in all indirect hernias (Fig. 2). Such structures can be reduced from their adventitious position upon the floor of the inguinal canal with the same ease with which they reached it. In fact, such reduction is achieved incidentally in the various operations devised. There is no logic, once this has been attained, in attempting to create a mesentery or a posterior peritoneal investment for a portion of the colon which normally has no such serous layer. These procedures are time-consuming and are technically more or less difficult, and they serve no useful purpose. It is quite sufficient in hernias of this type merely to close the sac, reduce it *en masse*, and repair the canal in the usual fashion.

TECHNIQUE

The sac in indirect inguinal hernia should always be opened high on its anterior surface, in order to avoid injury to the bowel if a sliding hernia should be present. This portion of the sac is almost invariably free and can be incised with safety. Once the sac is opened, the contents can be inspected and the true nature of the hernia determined. If colon forms a portion of the posterior wall of the sac as is the case in the ordinary sliding hernia, the following simple method of dealing with the sac and its contents is used. The reducible portions of the bowel are returned to the abdomen. A pursestring suture is then placed about the neck of the sac, extending as high on the anterior surface as possible and on the posterior side as close as is safe to the reflection of the peritoneum onto the colon. As this pursestring is pulled together, the bowel is turned upward and the sac is closed (Fig. 3). The sac with its contained intestinal floor is very readily dissected from the cord structures in a manner comparable to that employed in nonsliding hernias. This dissection must be carried well into the abdominal ring, and the sac and bowel reduced into the abdominal cavity. Closure is then effected as in the ordinary hernia by suture of the transversalis fascia snugly about the cord to reconstruct the internal ring. Further repair can be done according to the practice of the operator. It is our practice merely to repair the internal ring by a few

sutures of fine silk in the transversalis fascia which narrow this aperture to approximately its normal dimensions. The cord is then allowed to fall back into its normal position and the aponeurosis of the external oblique is reunited over it. However, if one chooses to suture the internal oblique or the other layers of the abdominal wall, this can be done after complete reduction of the sac as in the usual forms of hernia.

Burdick and Higinbotham have advocated division of the spermatic cord in hernias of this type, dropping the central end back into the properitoneal space and completely closing the canal. This is a worthwhile adjuvant in very large and very difficult hernias which involve the internal ring. It is not necessary, however, as a routine procedure in operations for sliding hernia.

It is frequently stated that the prognosis as to recurrence is much poorer in sliding hernias than in the ordinary variety. This has not been our experience. In a series of 24 cases of sliding hernia treated by the simple method described, there have been no known recurrences. Nor is there theoretical reason to expect more frequent failure than in other types of hernia. If anything, the bulk of the reduced colon should produce some measure of protection against herniation by acting as a pad or buffer against the newly repaired internal ring.

The extrasaccular or "pushing" hernia requires very little comment. As stated, this type of hernia is not to be expected in indirect sacs. It may occur, and unquestionably does, in a certain number of direct hernias, and the bladder is its most common occupant. Injury to this viscus is easily avoided if the sac is reduced unopened. In direct hernias in general, it is neither necessary nor desirable to open the sac. The sac in the ordinary types of direct hernia is usually broad, blunt, and domeshaped, and represents merely a bulge of peritoneum through a weakened inguinal floor. As a rule, these sacs are thick and opaque and contain a large amount of properitoneal fat. Moschcowitz has pointed out that properitoneal fat is usually sparse except in the regions close to a reflection of peritoneum onto the viscera. The fatty appearance of direct hernial sacs should warn the operator of the proximity of the bladder.

Opening into such sacs serves no useful purpose and unnecessarily expends time and operative manipulation. The fatty, opaque nature of the sacs demands the exercise of considerable time and care to avoid injury to the bladder if extrasaccular or parasaccular hernia is present. If the sac is isolated by dissection from the fibers of the transversalis fascia which course over it and is reduced unopened into the properitoneal space, the purposes of the operation are satisfied and risk of damage to the bladder is obviated. There remains but to suture the transversalis fascia over the defect and to re-enforce it by whatever method the operator deems adequate.

SUMMARY

The treatment of sliding hernia has been made unnecessarily difficult by the recent methods of dealing with the sac. These methods include laparotomy and reduction of the bowel from above, or the creation of a mesentery or a peritoneal investment for the posterior surface of the bowel which lies in the sac. This peritonization serves no useful purpose and renders the operation unnecessarily complicated. The colon and its blood vessels occupy an abnormal position upon the transversalis fascial floor of the canal. From this site they can be readily restored to the abdominal cavity and the canal repaired in the usual fashion.

REFERENCES

1. Bevan, A. D. Ann. Surg., 1930, 92: 754.
2. Burdick, C. G., and Higinbotham, N. L. Ann. Surg., 1935, 102: 863–874; discussion of Graham's paper (3).
3. Graham, R. R. Ann. Surg., 1935, 102: 784–787.
4. Hotchkiss, L. W. Ann. Surg., 1909, 50: 470.
5. Moschcowitz, A. V. Hernia. Johnson's Operative Therapeusis. Vol. 4, pp. 72–79. New York: Appleton & Co., 1915.
6. Walton, A. J. Ann. Surg., 1913, 57: 86–105.

THE MECHANISM OF ASPHYXIAL RESUSCITATION

Resuscitation with Inert—Asphyxiating—Gas in Advanced Asphyxia

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IT was shown in previous papers (1, 8, 9) that in advanced asphyxia resuscitation could be effected, after respiration had ceased and the circulation was rapidly failing, by rhythmic inflation and suction on the lung with an inert gas such as nitrogen or helium—asphyxial resuscitation.

Such resuscitation is effective far beyond the period[1] at which spontaneous recovery could take place by the cessation of the asphyxial procedure. Lougheed, Janes, and Hall have found, in obstructive asphyxia and drowning, that the "critical period" between the point at which respiration ceased and the point at which the asphyxial procedure stopped could not be much over 18 seconds if spontaneous recovery were to take place. If this period was extended even a few seconds longer, resuscitation by manual artificial respiration with inhalation of oxygen-carbon dioxide mixtures was not possible.

We propose now to present further data and a detailed analysis of the mechanism of this phenomenon which we have previously described.

TECHNIQUE

Dogs weighing 8 to 12 kilograms were anesthetized by the intraperitoneal injection of veterinary nembutal,[2] 1 cubic centimeter per 5 pounds. The animal was then placed on its back. In some experiments, a pharyngeal airway was inserted and a specially fitted metal face mask with inflation cuff on its rim was applied. In others, there was inserted an intratracheal tube surrounded by an inflatable rubber cuff to make the trachea leak proof. Asphyxia was produced either by obstructing completely the face mask or clamping the intratracheal tube. In other experiments asphyxia was produced by inhalation of inert gases such as nitrogen or helium.

Tracings on the kymograph were produced by recording mercury manometers which registered the blood pressure, respiration—intrapleural pressure—, intratracheal pressure, and resuscitation pressures. Blood pressure was recorded from the cannulized femoral artery. Intrapleural pressure or respiration was recorded by a fine brass intrapleural cannula.

For mechanical resuscitation the Emerson resuscitator was used. This apparatus inflates to 14 millimeters of mercury pressure and aspirates to minus 9 millimeters of mercury pressure; it was usually regulated to make 16 to 20 complete excursions or respiratory strokes per minute. It was connected, when needed, to the face or intratracheal tube as the case might be.

Vagus section was done in the mid neck. Carotid sinus denervation was done by exposing the bifurcation of the common carotid artery below the angle of the jaw and stripping 1 centimeter of the adventitia, away from the fork of the common carotid, from each of the following: common carotid, external carotid, and internal carotid artery. The angle of the fork itself was stripped and denervated. The stripped areas were painted with two applications of a 5 per cent alcoholic solution of phenol, and then swabbed clean with alcohol.

EXPERIMENTAL DATA

The legends to Figures 1 to 12 are self-explanatory so that we shall merely tabulate the experiments here for ready reference:

Experiment	Dog	Figure
Central depressing effect of carbon dioxide in asphyxia	36	1
Failure of asphyxial resuscitation after bilateral vagotomy	38, 39, 42	2, 3, 5
Successful but altered and sluggish asphyxial resuscitation in obstructive asphyxia following bilateral carotid sinus denervation	42, 59	4, 6
Failure of asphyxial resuscitation in nitrogen inhalation asphyxia after bilateral carotid sinus denervation	53, 54, 58	7, 8, 9
Oxygen saturation of the blood at various stages of obstructive asphyxia	Composite	11
Oxygen saturation of the blood at various stages of nitrogen inhalation asphyxia	Composite	12

With the technical collaboration of Eugene Ostrow.

From the Laboratory of Surgical Research, the Department of Surgery and the Thoracic Surgical Service, The New York Medical College and Flower-Fifth Avenue Hospitals.

[1]Generally we have started resuscitation 45 seconds or more after respiration ceased, at the variable "critical point" where the heart action becomes markedly altered and irregular. Asphyxial resuscitation has been possible in some instances even 2½ minutes or more after cessation of respiration.

[2]Sodium pentobarbital, 1 grain per cubic centimeter.

TABLE I.—REGULATION OF CIRCULATION AND RESPIRATION

Carotid sinus nerves and cardioaortic nerves are complementary	Exert normally a reflex tonic inhibitory action on the vasomotor center, cardiac and respiratory centers and on adrenalin secretion	
Carotid sinus nerves		
Section of nerves		Rise of blood pressure
Increased pressure in carotid sinus	Increased inhibition increase of action currents	Vasodilation fall of blood pressure depression of respiration
Decreased pressure in carotid sinus	Diminished inhibition decrease of action currents	Vasoconstriction rise of blood pressure
Cardioaortic nerves		
Section of nerves		Rise of blood pressure
Increased pressure in aorta or stimulation of central cut end	Increased inhibition increase of action currents	Vasodilation fall of blood pressure depression of respiration vasodilation and fall of blood pressure due to inhibition of vasoconstrictors and stimulation of vasodilators
Decreased pressure in aorta	Decreased inhibition decrease of action currents	Vasoconstriction rise of blood pressure
Effect of various factors on respiration		
Excess of carbon dioxide, increased temperature	Acting directly on respiratory center	Stimulates breathing
Lack of carbon dioxide, lack of oxygen	Acting directly on respiratory center	Depresses breathing
Excess of carbon dioxide, lack of oxygen, fall of blood pressure	Acting within aorta and carotid sinus; reflex via carotid sinus and aortic nerves	Stimulates breathing
Lack of carbon dioxide, rise of blood pressure	Acting within aorta and carotid sinus; reflex via carotid sinus and aortic nerves	Depresses breathing

PHYSIOLOGICAL CONTROL OF CIRCULATION AND RESPIRATION

Before analyzing the possible factors at play in resuscitation, without benefit of oxygen, with inert—asphyxiating—gas, it may be appropriate here to recall a few of the important points in the physiological control of circulation and of respiration.

It is known that afferent impulses passing by way of the carotid sinus nerves, the aortic and vagus nerves to the medulla exert an influence on the vasomotor center, the cardiac center, the respiratory center, and on adrenalin secretion (1, 3). In fact, electric action currents can be recorded, in a cephalad direction, in the carotid sinus nerves, the aortic, and the vagus nerves. In a similar manner, action currents can be detected, in a direction away from the spinal cord, in the sympathetic, vasomotor, and phrenic nerves.

The carotid sinus nerves, the aortic and vagus nerves form a closely functioning group which in general exerts an inhibitory influence on the vasomotor and respiratory centers. Because of this regulation, the sinus and aortic nerves together are referred to as "buffer" nerves by Wright; they are sensitive to changes of pressure, pH, oxygen, and carbon dioxide within the carotid sinus and aortic arch, and relay their messages to the medullary centers. The carotid sinus nerve joins the glossopharyngeal or ninth nerve; it may send fibers to the sympathetic trunk and vagus. Afferent impulses from the aorta, heart, and lungs travel in fibers which join the vagus (Table I and Fig. 10).

The most generally known reflex by way of the vagus is that of Hering and Breuer. In the experiments of Head, referred to by Wright, forceful inflation of the lung causes a reflex expiratory effort; a forceful deflation or suction on the lung (and not a passive expiration) causes a reflex inspiratory effort. These experiments only partly confirm the Hering-Breuer reflex which presupposes both inspiratory and expiratory fibers in the vagus: at the height of inspiration the latter is stopped by inhibitory impulses from the lung to the respiratory center; at the normal depth of expiration the latter is stopped by impulses to the respiratory center which initiate inspiration. However, if the vagus be cut, action currents can be detected in the distal cut end of the nerve on inflation and suction and not on mere passive expiration. These considerations emphasize the importance of suction as well as inflation, in resuscitation procedures, to stimulate the medullary centers reflexly.

There is evidence that central irradiation from one medullary center to the other may occur. Thus, in the study of sinus arrhythmias, Heymans (Wright, p. 305) concluded that this phenomenon is due to direct irradiation from the respiratory to the cardiac center—"isolated head" experiment. Conversely, it would seem that irradiation from the cardiac or vasomotor centers or both to the respiratory center can occur; for it will be noticed in our experiments that in asphyxial resuscitation with inert gas, the circulation recovers regularly before spontaneous respiration begins.

In Figure 1 and other experiments not shown it can be seen that in the presence of asphyxia, 10 per cent carbon dioxide added to nitrogen 90 per cent, prevents suck and blow—asphyxial—resuscitation. This could indicate a central depressant effect of carbon dioxide on the medullary centers. That carbon dioxide depresses the respiratory center in states of moderate asphyxia also is shown by the following experiment (Wright, p. 399):

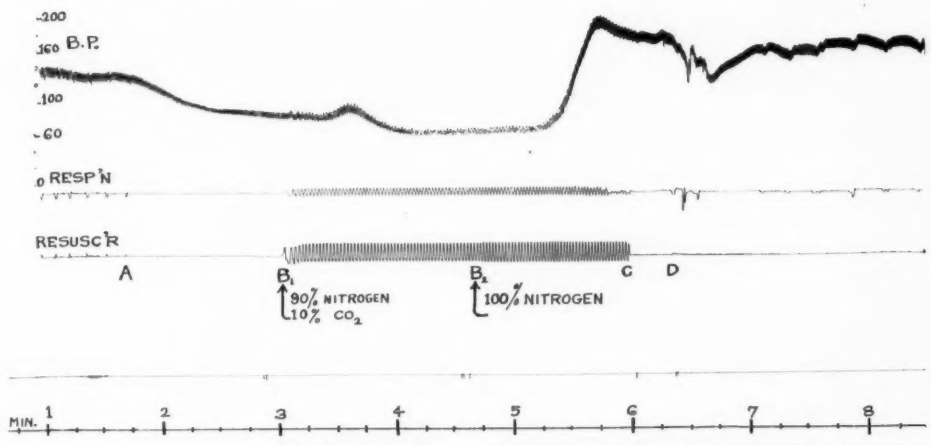

Fig. 1. Dog 36. Phenomenon of asphyxial resuscitation. An inert gas (100% nitrogen) used with positive-negative resuscitator is successful after failure with 90 per cent nitrogen with 10 per cent carbon dioxide. Carbon dioxide, in the presence of asphyxia, apparently prevents resuscitation by an inert gas. Through a leak-proof intratracheal tube, nitrogen inhalation asphyxia has been given with an arrangement for "blow-off" of the expired air so as to prevent carbon-dioxide accumulation. At *A*, the respiration has ceased; B_1, resuscitator started using nitrogen with 10 per cent carbon dioxide; B_2, pure nitrogen is used with the resuscitator; *C*, resuscitator off, tracheal tube is connected with nitrogen; *D*, spontaneous respiration starts (resuscitator pressures: plus 14 mm. minus 9 mm. Hg.).

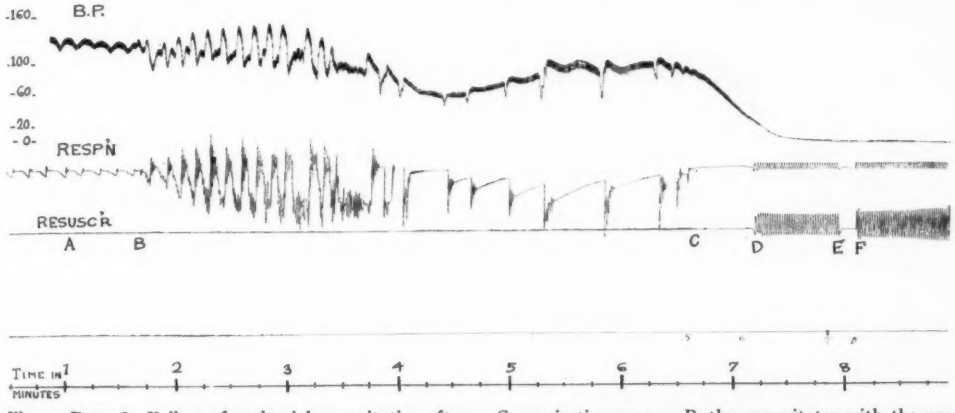

Fig. 2. Dog 38. Failure of asphyxial resuscitation after double vagotomy. *A*, After double vagotomy in the midneck; *B*, asphyxia begun by clamping intratracheal tube; *C*, respiration ceases; *D*, the resuscitator with the use of nitrogen was instituted but resuscitation could not be brought about.

"Decerebrate cat. Sinus nerves and vagi cut.
"Pulmonary ventilation (5 mins.): breathing air, 3.5 litres; breathing 3 per cent. CO_2 plus air, 11.5 litres; breathing 3 per cent CO_2 plus 7.5 per cent. O_2, 6.7 litres."

Several hypotheses presented themselves to us to explain asphyxial resuscitation; thus it could be due to:

1. Massage action on heart and great vessels in the thorax, and intrapleural and mediastinal pressures varying synchronously with the resuscitator pressures; "milking" action on alveolar capillaries.[1]

2. Mobilization of unused oxygen sources which might still be present in the blood vessels and tissues, by initiating return of circulation as described under paragraph 1.

3. A washing out of carbon dioxide from the blood by the resuscitator, thus removing a sub-

[1]We believe that the factors mentioned in hypothesis 1 have a very definite beneficial effect on the circulation.

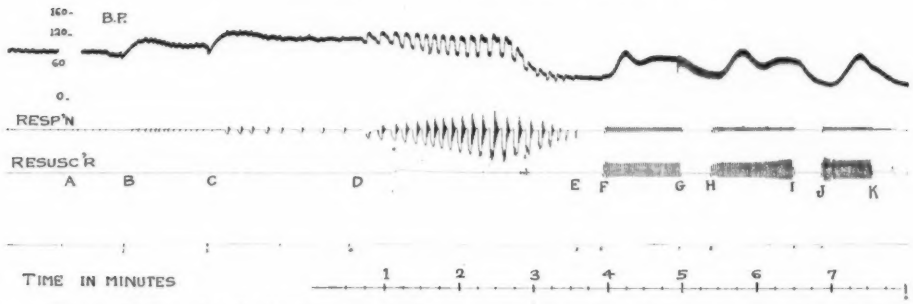

Fig. 3. Dog 39. Failure of asphyxial resuscitation after double vagotomy. *A*, Control, before vagotomy; *B*, left vagus is cut in the mid-neck; *C*, right vagus cut in the mid-neck; *D*, asphyxia begun by clamping intratracheal tube; *E*, respiration ceases; *F* to *G*, resuscitator with nitrogen applied; *G* to *H*, tracheal tube connected to nitrogen only; *H* to *I* and *J* to *K*, resuscitator with nitrogen reinstituted, but the blood pressure could not be maintained and spontaneous respirations did not occur. Following this the animal was resuscitated with oxygen (not shown).

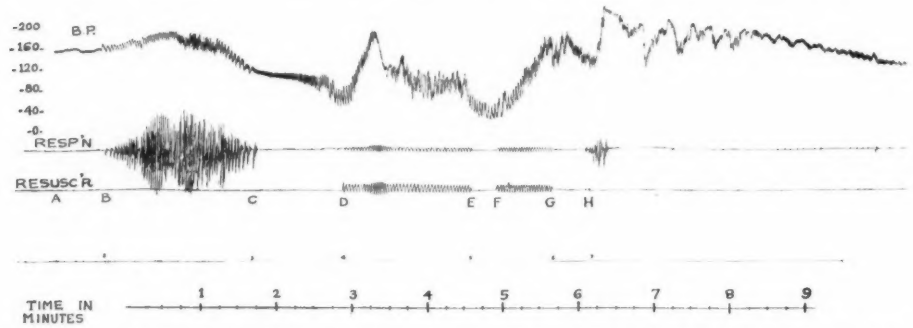

Fig. 4. Dog 42. Altered and sluggish asphyxial resuscitation after double carotid sinus denervation. *A*, After carotid sinuses were denervated; *B*, asphyxia started by clamping tracheal tube; *C*, respiration ceases; *D* to *E*, resuscitator with nitrogen in action; *E* to *F*, trachea connected to nitrogen only; *F* to *G*, resuscitator with nitrogen was again brought into action; *G* to *H*, trachea was connected to nitrogen only; *H*, spontaneous respirations were effected, and tracheal tube opened to the atmospheric air.

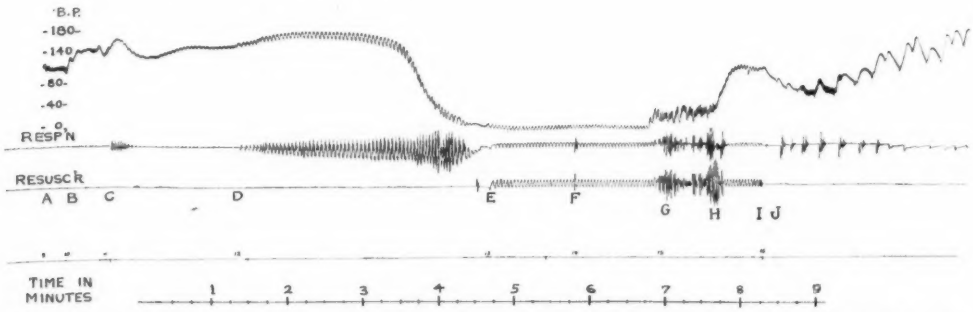

Fig. 5. Dog 42. Continuation of previous experiment. *A*, Control; *B*, left vagus was cut in mid-neck; *C*, right vagus was cut; *D*, asphyxia was started by clamping tracheal tube. Notice the precipitous fall of the blood pressure even before respiration ceased. *E* to *F*, Resuscitator with nitrogen was unsuccessful in effecting resuscitation; *F* to *G*, resuscitator with oxygen was also unsuccessful; *G* to *H*, while resuscitator was in action, the heart was massaged, with the chest closed, by bilateral manual compression close to the sternum; *I*, resuscitator was discontinued and tracheal tube opened to the air; *J*, spontaneous respiration started.

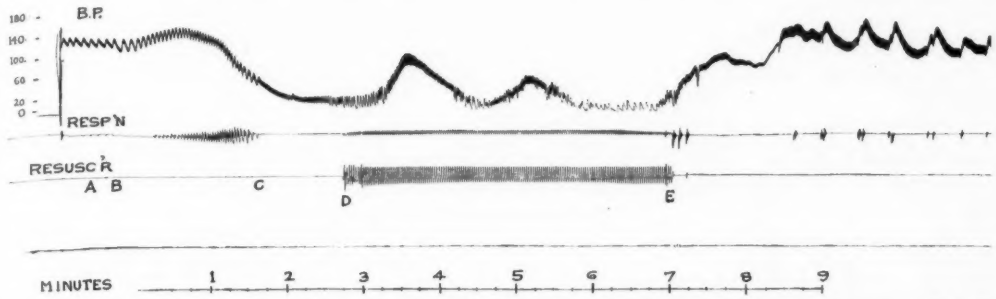

Fig. 6. Dog 59. Altered and sluggish asphyxial resuscitation after double carotid sinus denervation. *A*, After carotid sinuses were denervated; *B*, asphyxia started by clamping tracheal tube—notice the initial period of apnea that follows and the sharp fall of blood pressure even before the respiration ceases; *C*, respiration ceases; *D* to *E*, resuscitator with nitrogen in action; *E*, blood pressure starts to rise and spontaneous respirations begin; the resuscitator is discontinued and the tracheal tube is opened to the atmosphere.

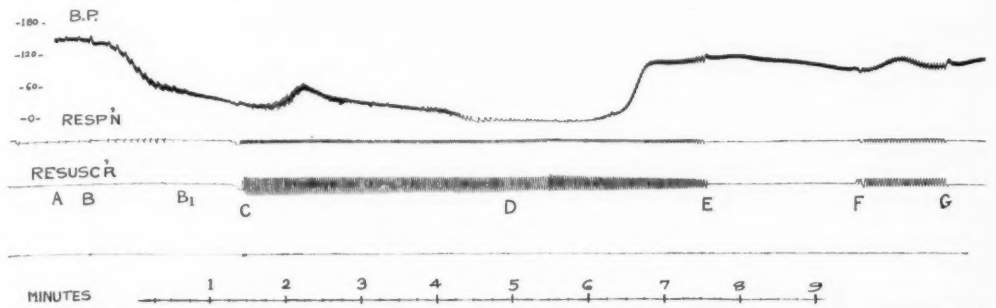

Fig. 7. Dog 53. Failure of asphyxial resuscitation after double carotid sinus denervation. *A*, After denervation; *B*, through a leak-proof intratracheal tube, nitrogen inhalation asphyxia has been started with an arrangement for "blow-off" of the expired air so as to prevent carbon dioxide accumulation. Notice the sharp fall of the blood pressure even before the respiration ceases at B_1. *C* to *D*, Resuscitator with nitrogen fails to resuscitate; *D* to *E*, resuscitator with oxygen restores the circulation; *E* to *F*, trachea connected with oxygen; *F* to *G*, resuscitator with oxygen started again in an attempt to initiate spontaneous respiration.

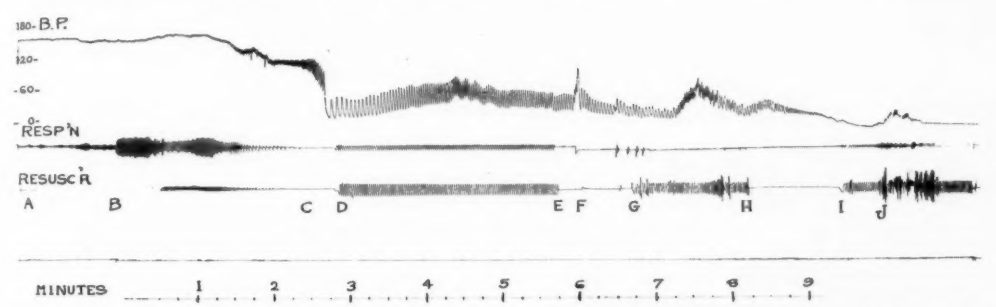

Fig. 8. Dog 54. Failure of asphyxial resuscitation after double carotid sinus denervation. *A*, The carotid sinuses have been denervated. Notice the typical denervation effect: elevation of the blood pressure, small pulse pressure and rapid heart rate; *B*, nitrogen asphyxia started as for previous experiment; *C*, respiration ceases—notice the sharp fall of blood pressure following this; *D* to *E*, resuscitator with nitrogen unsuccessful; *E* to *G*, tracheal tube connected to nitrogen. Although several spontaneous respirations were taken in the interval *E* to *G*, tracheal tube was not opened to atmosphere because blood pressure was very low. *G* to *H*, Resuscitator with nitrogen tried again; *H*, tracheal tube opened to atmospheric air; *I*, resuscitator with oxygen, plus "external heart massage," unsuccessful.

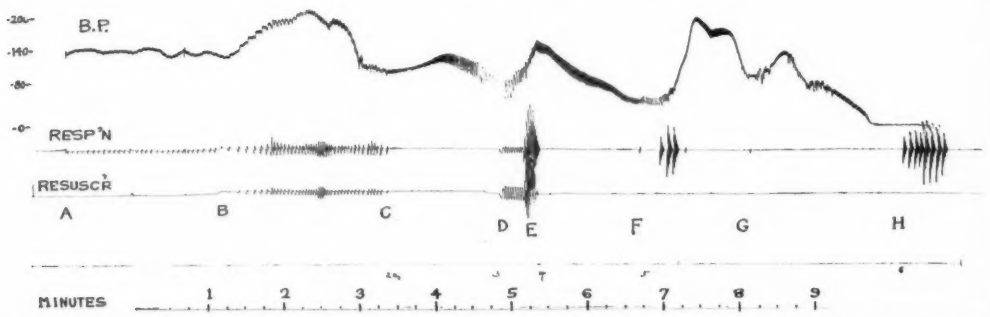

Fig. 9. Dog 58. Failure of asphyxial resuscitation after double carotid sinus denervation. *A*, Carotid sinuses have been denervated; *B*, nitrogen asphyxia is started; *C*, respiration ceases; *D* to *E*, resuscitator with nitrogen in action; *E*, spontaneous respirations are taken and the tracheal tube is opened to the atmosphere. At *F* and *G* further spontaneous respirations are taken but circulation fails to continue. At *H* agonal respirations are taken and death follows.

stance depressing to the medullary centers in the presence of asphyxia.

4. A reflex mechanism to the medullary centers, by way of the vagus or other nerves, concerned with circulation and respiration.

5. A combination of two or more of the above.

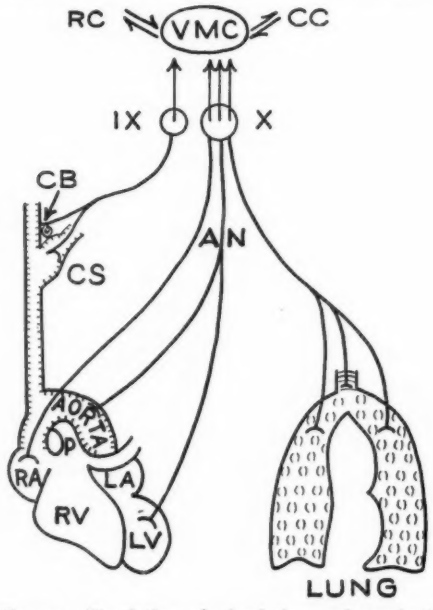

Fig. 10. Regulation of circulation and respiration. Scheme of afferent impulses to the medullary centers by way of the carotid sinus nerves and the cardioaortic and vagus nerves. *RC*, Respiratory center; *CC*, cardiac center; *VMC*, vasomotor center; *IX*, glossopharyngeal nerve; *X*, vagus nerve; *CB*, carotid body; *CS*, carotid sinus; *AN*, aortic nerve; *CCA*, common carotid artery.

Bilateral vagus section in the mid-neck prevents resuscitation with inert gas (Figs. 2, 3 and 5). Carotid sinus denervation may (Figs. 7, 8, and 9) or may not (Figs. 4 and 6) prevent resuscitation. It is evident, therefore, that the phenomenon is primarily a reflex mechanism (hypothesis 4) in which the vagus (cardioaortic, pulmonary fibers or both) is indispensable. The carotid sinus nerve is vitally concerned but not always indispensable in asphyxial resuscitation; its rôle, therefore, may be that of a most important regulator, sending impulses to the medullary centers. It is as if the elevation of blood pressure, which is initiated reflexly through the afferent fibers in the vagus, may require the accessory regulatory stimuli of the carotid sinus nerve to maintain such elevation.

We have seen above that with nitrogen resuscitation the circulation recovers regularly before spontaneous respiration begins. Three hypotheses present themselves:

1. The afferent reflex impulses go first to the cardiac or vasomotor center or both and irradiate to the respiratory center which is at first refractory.

2. The nerve impulses first reach the respiratory center, which as yet does not respond, and irradiate to the cardiovasomotor centers.

3. The impulses reach the centers simultaneously, the respiratory center being refractory at the start.

Once the circulation is more or less definitely re-established by suck and blow resuscitation with inert gas, the animal may be kept alive for 1, 2, 3 or more minutes longer, as the case may be, if the procedure is persisted in instead of the use of the resuscitator being discontinued. This is quite remarkable, since when the respiration ceases in asphyxia, the oxygen saturation of the

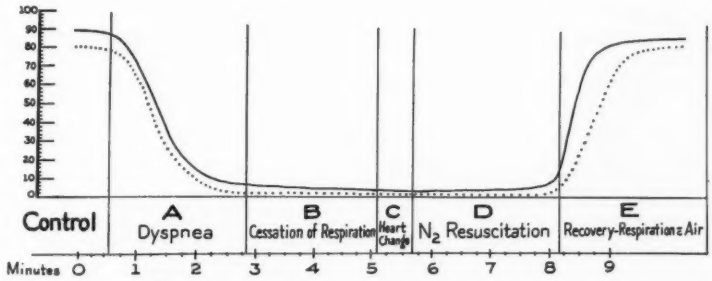

Fig. 11. Composite graphs of oxygen saturation of the blood at various stages of obstructive asphyxia. Solid line, arterial blood from femoral artery; dotted line, venous blood from jugular vein. Vertical scale on left indicates percentage saturation of the blood with oxygen. Asphyxia starts after control period. *A*, Period of dyspnea; *B*, period of cessation of respiration—secondary apnea; *C*, "critical period" of the heart, the sign of impending failure; *D*, period during which suck and blow resuscitation with nitrogen is in action; *E*, period of recovery. The blood pressure had already risen and the heart beat recovered toward the end of the previous period, *D*. At the start of period *E*, spontaneous respiration having occurred, the tracheal tube is left open to the atmospheric air.

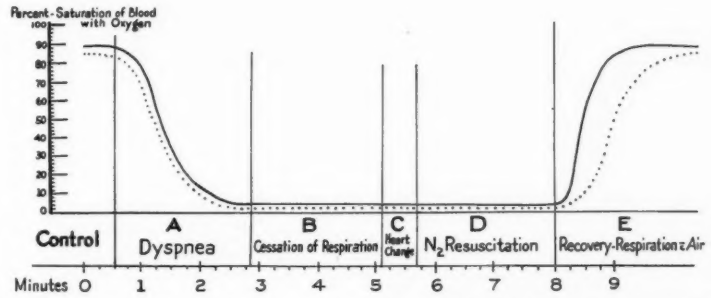

Fig. 12. Composite graphs of oxygen saturation of the blood at various stages of nitrogen inhalation asphyxia. Description of this graph same as for Figure 11.

blood is already at an extremely low level (Figs. 11 and 12).

Blood gas analyses also show a high oxygen unsaturation (low oxygen content) at the institution of asphyxial resuscitation; at later periods of the procedure, the unsaturation may increase slightly and this could indicate utilization of oxygen by such vital organs as the heart and brain. Some of the oxygen in the pulmonary capillaries could also be washed out into the alveoli and aspirated into the resuscitator. The oxygen in the blood vessels is the first available; but mobilization of oxygen from capillary pools[1] and the tissues is a possibility to consider. The washing out of carbon dioxide from the blood into the alveoli and resuscitator, by lessening medullary depression, may also be a factor in sustaining and prolonging life.[2]

SUMMARY

We have seen that advanced states of asphyxia were produced in our experiments by obstruction of the trachea or by inhalation of inert—asphyxiating—gases such as nitrogen or helium. If the asphyxiating procedure is not stopped within 20 to 30 seconds after the cessation of respiration, spontaneous recovery usually does not occur. However, if within periods of 45 seconds to 2½ minutes after cessation of respiration suck and blow resuscitation with inert—asphyxiating—gas is applied, resuscitation of the circulation and respiration can be accomplished in 85 per cent of instances. The addition of 10 per cent carbon di-

[1]We have found regular evidence of shock in asphyxiated animals: serous peritoneal exudate, edema of the intestines, capillary dilation in the liver and spleen, arterial constriction and venous dilation in the mesentery of the intestine. It is known that in shock, capillary dilation, stagnation of blood and tissue edema occur.

[2]Alveolar and blood gas analyses for oxygen and carbon dioxide, and the question of oxygen mobilization is the subject of a paper to follow.

oxide to the inert gas inhibits resuscitation. Bilateral vagus section before asphyxia is started prevents asphyxial resuscitation with inert gas. The carotid sinuses are also greatly concerned in this phenomenon. Carotid sinus denervation carried out before obstructive asphyxia gives an altered and sluggish asphyxial resuscitation; denervation before nitrogen inhalation asphyxia prevents asphyxial resuscitation.

Asphyxial resuscitation is primarily a reflex phenomenon which is initiated most efficiently by suck and blow resuscitation within safe limits of pressure. Thus, resuscitation with inert gas can be accomplished by suck and blow (16–20 strokes per minute, with plus 14 mm. Hg., minus 9 mm. Hg.) in 85 per cent of instances. On the other hand, resuscitation with inert gas can be accomplished in only 15 to 20 per cent of instances by one of the following methods: manual artificial respiration with nitrogen inhalation, rhythmic pressure with nitrogen at plus 12 to 14 millimeters of mercury or rhythmic suction on the lung at 8 to 12 millimeters of mercury alternating with nitrogen inhalation. These facts would indicate that asphyxial resuscitation is primarily a reflex from the vagus endings in the lungs to the medullary centers. Moreover, the greater rhythmicity and adequate combined inflation and active deflation of the lung by the suck and blow resuscitator, appears more effectively to stimulate the pulmonary vagal endings.

CONCLUSIONS

1. A powerful reflex mechanism allows resuscitation with rhythmic pressure and suction on the lungs to take place with the use of only inert gas and not oxygen.

2. The mechanism of this phenomenon has been analyzed.

3. Clinically, in advanced asphyxia when the respiration has ceased, advantage should be taken of this phenomenon by the administration of oxygen or oxygen-carbon dioxide by the suck and blow type of resuscitation, within safe limits of pressure.

REFERENCES

1. Birnbaum, G. L., and Thompson, S. A. J. Am. M. Ass., 1942, 118: 1364.
2. Coryllos, P. N. Surg. Gyn. Obst., 1938, 66: 698.
3. Editorial. J. Am. M. Ass., 1941, 117: 1185.
4. Henderson, Y., and Turner, J. McC. J. Am. M. Ass., 1941, 116: 1508.
5. Hering, E., and Breuer, J. Sitzber. Akad. Wissensch., Wien, 1868, 57: 672; 1868, 58: 909.
6. Howell, W. H. A Text Book of Physiology. Philadelphia and London: W. B. Saunders, 1921.
7. Lougheed, D. W., Janes, J. M., and Hall, G. E. Canad. M. Ass. J., 1939, 40: 423.
8. Thompson, S. A., and Birnbaum, G. L. Proc. Soc. Exp. Biol., N. Y., 1941, 48: 203.
9. Thompson, S. A., and Birnbaum, G. L. Resuscitation in advanced asphyxia; rôle of positive and negative pressures. Surgery. (In press)
10. Wright, S. Applied Physiology. New York and London: Oxford University Press, 1934.

THE USE OF ESTRADIOL DIPROPRIONATE IN THE TREATMENT OF ESSENTIAL DYSMENORRHEA

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IN a previous paper discussing estrin therapy for essential dysmenorrhea (2), it was pointed out that the dramatic and complete relief from cramps that can be produced by estradiol benzoate was associated with an unexpected change in ovarian function. From evidence obtained by endometrial biopsy, it was demonstrated that a cramp-free period followed such therapy only when the formation of a secretory endometrium was prevented, apparently due to the suppression of ovulation. Later work showed that this result could be obtained as well with oral stilbestrol (1), when given according to certain specifications, as with estradiol benzoate. The purpose of the present paper is to confirm these previous observations by reporting the results with a third estrogen—estradiol diproprionate, and to emphasize certain principles that are equally important in the treatment of dysmenorrhea with any potent estrogenic compound.

If an adequate dose of estrogen is given early enough in the menstrual cycle and continued over a sufficient length of time, not only will it prevent the formation of a secretory endometrium, but it will produce an endometrial proliferation from which bleeding occurs when the estrogen is withdrawn. It seems probable that the first effect is due to an inhibition of the follicle-stimulating hormone by estrogen, thereby preventing the maturation of the young ovarian follicle so that ovulation that month cannot occur. This transient suppression of ovulation explains the absence of a secretory endometrium after treatment. The second effect—that of bleeding following withdrawal of estrogen—is unaccompanied by any pain whatsoever for reasons so far unexplained. If estrogen is given too late in the cycle, however, when the graafian follicle is no longer dependent on a growth stimulus from follicle stimulating hormone, then therapy is ineffective in prevention of ovulation and the cramps in that case will not be completely eliminated.

It has been found that the effective dose of estradiol benzoate (progynon-B), to obtain these results consistently was 6 injections of 1.66 milligrams subcutaneously, started on or before the 6th day of the cycle and repeated every 3d day. The disadvantages of this treatment are that it is expensive and that 6 hypodermic injections of this dose appear to be necessary. Oral stilbestrol is a more convenient and less expensive type of estrogen therapy. Consistent results are generally obtained with a dose of 1 milligram daily for 20 days, started on the 2d or 3d day of the cycle. Since about 20 per cent of patients given stilbestrol are likely to have gastrointestinal symptoms of varying intensity, this preparation is not, however, ideal.

Presented at the Massachusetts General Hospital during the Clinical Congress of the American College of Surgeons, Boston, November 7, 1941.

RESULTS

In the last year and a half, 33 patients with essential dysmenorrhea have received over 260 injections of estradiol diproprionate (diovocylin). No nausea or other toxic effects that could be ascribed to this medication were encountered. Treatment was given primarily to afford clinical relief from monthly pain; secondly, it was hoped to determine the exact timing of injections that could be given to cause painless estrin-withdrawal bleeding at approximately monthly intervals. A large majority of the injections were successful in eliminating cramps during the month or more of treatment, a statistical analysis, however, of the successes and failures does not yield pertinent details of response. Thus, there were approximately 130 menses following treatment and of these 88, or 68 per cent, were completely painless. However, in 11 per cent the pain, though better, was not entirely eliminated, and in 27, or 20 per cent, the cramps were as severe as when no medication was given. But some of these painful periods were delayed and did not occur for an interval of 4 or more weeks after the end of the injections. Such an interval suggests that a complete ovulatory cycle might have occurred after treatment; such a result cannot be properly included in the "failures." These complications make it difficult to present a clear statistical analysis and suggest the desirability of presenting a discussion of typical examples of various responses rather than a table of figures.[1]

[1]The charts here used are copied directly from the records of 6 patients, all of whom gave a history of consistent menstrual cramps at regular intervals of approximately 4 weeks.

Below are discussed and graphically illustrated examples of the following: (1) Failure to respond to treatment due either to an inadequate dose or to starting medication too late in the cycle, or both; (2) typical response after an adequate dose started early enough in the cycle; (3) the timing of adequate doses to produce consecutive anovulatory flows at approximately monthly intervals; (4) further evidence that elimination of cramps after estrogen is associated with suppression of ovulation.

1. *Failure to respond to treatment due to either an inadequate dose or starting medication too late in the cycle or both.* In previous experience with dosage of estradiol benzoate, it was shown that an adequate amount of this estrogen must be started at least by the 6th day of a 28 day cycle to prevent ovulation. On this basis we first tried an injection of 5 milligrams of estradiol diproprionate on the 6th day, and repeated it 10 days later. It was found that this dose and timing did not give consistently satisfactory results. Either ovulation was not consistently suppressed or else the endometrium was not always sufficiently stimulated to break down later into withdrawal bleeding (see Charts 1 and 2). Therefore, in all but 23 of the 260 injections, 10 milligrams was used. It is recognized that this may prove to be more than the minimum necessary to obtain the desired ends; the use of large doses, however, gave consistently predictable results.

2. *Typical response after an adequate dose started early enough in the cycle.* If a single dose of 10 milligrams of estradiol diproprionate is given within the first 6 days of a cycle, a painless "withdrawal" flow generally will follow in about 2 weeks (Chart 3). This is longer than the interval to bleeding after estradiol benzoate; when a total of 10 milligrams of the benzoate is given, bleeding usually occurs in from 4 to 10 days, the average being 8 days (1). The interval from a single injection to withdrawal bleeding varies, however, from individual to individual. In the present series this "withdrawal interval" varied from 10 to 17 days, with the mean at 13 days (see Chart 8). One might predict that it should be possible to maintain the endometrium almost indefinitely by repeated injections at short intervals if our assumption of the suppression of ovulation is correct. One should be able to produce an amenorrhea of any desired duration by starting an injection of 10 milligrams early in the cycle and repeating it, say, every 10 days—before an estrogen-withdrawal breakdown of the endometrium can occur. Conversely, if estrogen when given early does not suppress ovulation, then one could confidently predict that menstruation will occur when the corpus luteum atrophies and progesterone is withdrawn, irrespective of concurrent estrogen medication. In the present series there was ample evidence that bleeding could be postponed at will by giving 10 milligrams early in the cycle and repeating the dose before withdrawal bleeding takes place (Chart 4). This can be interpreted only on the basis that ovulation has been suppressed and the pituitary-ovarian cycle held in abeyance until such estrogen therapy is stopped. It is not, however, ideal to produce a period of amenorrhea of 6 or more weeks by repeated injections at short intervals since the endometrium will become so hyperplastic that a profuse or prolonged flow generally follows the cessation of such treatment (Chart 4).

In order to prevent the endometrial hyperplasia that results from repeated stimulation without interruption, the endometrium may be allowed to break down and bleed after each injection before the dose is repeated. It is thus often possible to produce anovulatory periods twice a month for several months by repeating the injection on the first day of each episode of withdrawal bleeding (Chart 5). Unfortunately however, this simple plan of treatment cannot consistently be counted upon because of the variability of the "withdrawal interval" noted in Chart 8. It is well to emphasize once more that two effects result from withdrawal of estrogen—after the dose here used, the visible effect is onset of bleeding generally in from 10 to 17 days; the invisible effect is release of the pituitary to produce gonadotropin. The interval to bleeding has already been tabulated, but we have no data on the interval to pituitary release. There is no reason to believe that the two effects are necessarily synchronous. From a study of our cases it is apparent that an interval of more than 14 days between injections may be sufficient for the pituitary to escape from estrogen-repression; follicle-stimulating hormone is then produced, a follicle started, and the second dose may be useless to prevent ovulation. It should be clear, therefore, that if repetition of the dose is always delayed until onset of withdrawal bleeding, and if the latter should not occur for 16 or 17 days (see Chart 8), then such an interval may allow a follicle to develop to a point no longer vulnerable to further follicle-stimulating hormone repression. For example, even if, in Chart 2, a dose of 10 milligrams had been given at the onset of the withdrawal bleeding that occurred after a 16 day "withdrawal-interval," it might well have had no effect on ovulation that probably occurred 4 or 5 days later.

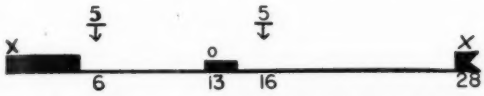

Chart 1[1]. M.G.H.—E.G. This patient had noted a little bleeding in 3 out of the 6 previous months at intervals of 13, 15, and 15 days from onset of menses. These episodes of spotting just 2 weeks before the next menses are believed to have been associated with the occurrence of ovulation at that time during those months. In this chart it is probable that the painless flow represented by *O* on the 13th day was again associated with ovulation since it occurred 15 days before the onset of a typical crampy period. The dose of 5 milligrams on the 6th and again on the 16th days, appears in this case to have had no effect on the ovarian cycle.

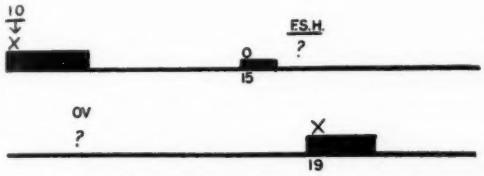

Chart 3. J.V.M.—S.B. A single dose of 10 milligrams given on the first day of the cycle in this case produced a characteristic painless and scanty flow after a "withdrawal interval" of 14 days (see *O*). The next menses with cramps occurred 32 days after this withdrawal bleeding, a total of 46 days from the single injection. One can postulate that ovulation probably occurred about the 5th day of the second month (see *? OV*), following release of gonadotropin from the pituitary about 2 weeks previously (see *? FSH*). The scanty flow at *O* in this case cannot be explained on the basis of a little spilling over at time of ovulation (see Chart 1) since in that case the crampy menses would have occurred 2 weeks later instead of in 32 days.

There are, therefore, two disadvantages to the use of a "rule-of-thumb" that the dose may be repeated indefinitely on the first day of withdrawal bleeding. First, although if successful the "periods" are painless, yet it is a nuisance to the patient to have bleeding every 2 weeks. Second, if the interval to bleeding should be more than 2 weeks, there is a distinct possibility that the second injection will be too late to be effective.

3. *Timing injections to produce consecutive anovulatory flows at approximately monthly intervals.* Since it is neither ideal to give a long series of injections producing endometrial hyperplasia (Chart 4) nor to withhold the next injection until onset of bleeding, we have tried to plan a compromise schedule of timing injections. The ideal timing of repeated injections over several consecutive months would have to keep the pituitary constantly repressed, yet allow painless endometrial breakdown to occur at approximately monthly intervals. This can generally be done by following a definite schedule (Chart 6). The first injection in such a scheme must be given by the 6th day after onset of menstruation, the second 10 days later, and the third 2 weeks later. In this 2 week interval, withdrawal bleeding is likely to occur. If there is no bleeding in this time, however, injections are nevertheless continued according to plan. Thereafter, the injections are given 10 days, 10 days, and 14 days apart, and this timing of 3 injections may be repeated yet again. This plan of therapy with estradiol diproprionate, then, necessitates only 2 or 3 injections a month, a distinct advantage over the 6 injection treatment found necessary in the use of the benzoate ester in the handling of these cases. When estrogen stimulation of the endometrium is consecu-

[1]In each chart each line represents 28 days. *x*, indicates cramps; *o*, indicates absence of cramps; dose in milligrams of estradiol diproprionate indicated by arrows.

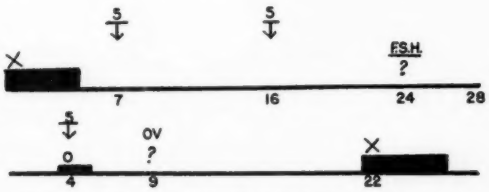

Chart 2. M.G.H.—V.F. In this chart, a slight spotting without pain, *O*, occurred 16 days after the second dose of 5 milligrams. A third dose of 5 milligrams on the day this spotting appeared did not prevent cramps during the flow 18 days later. It may be postulated that the first 2 doses repressed the pituitary until about the 24th day—(see *? F.S.H.*). Follicular development, started about that time, progressed too far to be affected by the third dose and probably resulted in ovulation on about the 9th day of the 2d month (*? OV*) and dysmenorrhrea 2 weeks thereafter. The scantiness of the withdrawal bleeding induced by 2 doses of 5 milligrams indicates that this amount of medication provides a minimum proliferative stimulus to the endometrium.

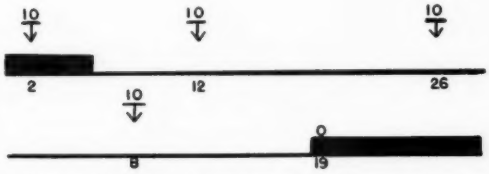

Chart 4. J.V.M.—R.P. A dose of 10 milligrams given on the 2d day of the cycle was repeated three times without the occurrence of withdrawal bleeding until 11 days after the last injection. The flow that then occurred was painless, but prolonged and profuse due to breakdown of a hyperplastic endometrium. The 4 injections here produced an amenorrhea of 47 days. This could have been prolonged almost indefinitely by maintaining the endometrium with repeated doses at short intervals, but the bleeding that would have eventually followed the last dose would have been undesirably profuse.

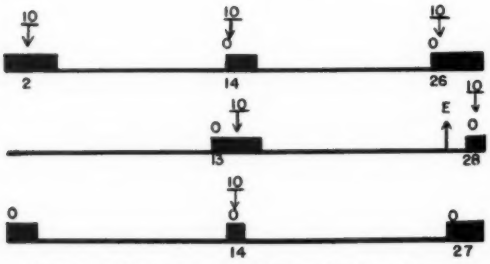

Chart 5. J.V.M.—S.B. In this case the dose of 10 milligrams was repeated on the first or second day of "withdrawal bleeding" which occurred at intervals of 12, 12, 15, 14, 14, and 13 days from the injections. In all of these flows there was absence of cramps, *O*. An endometrial biopsy at onset of the 5th flow (see *E* at end of the 2d month) showed estrogen effect only with absence of secretory pattern. At times the flow was scanty. Except for the nuisance of having periods twice monthly, the medication here given proved satisfactory in the control of severe cramps over the 3 month period here charted.

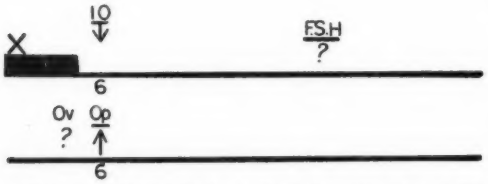

Chart 7. J.V.M.—M.G. A single injection of 10 milligrams was given on the 6th day of the cycle. Twenty-eight days later an endometrial biopsy was taken and an exploratory laparotomy performed (see *OP*). At this time the patient had as yet had no period and, although previously regular, was already 1 week late. The biopsy showed a typical early secretory pattern with well marked subnuclear vacuoles (Fig. 1). There was found fresh blood in the pelvis and a very recent corpus hemorrhagicum was demonstrated in one ovary. These findings showed that ovulation had occurred at least within 2 or 3 days (see *? OV*) due to release of follicle stimulating hormone from the pituitary about 2 weeks earlier (see *? F.S.H*). One can assume with confidence that a painful period would have occurred, as in Chart 3, in another 2 weeks if operation had not been performed. In this patient the single injection failed to stimulate the endometrium sufficiently even to produce a scanty withdrawal bleeding. After 28 days of amenorrhea, ovulation occurred. We believe that such evidence proves incontrovertibly that in this case the estrogen temporarily suppressed or delayed ovulation, and thus supports the contentions elaborated in the other charts.

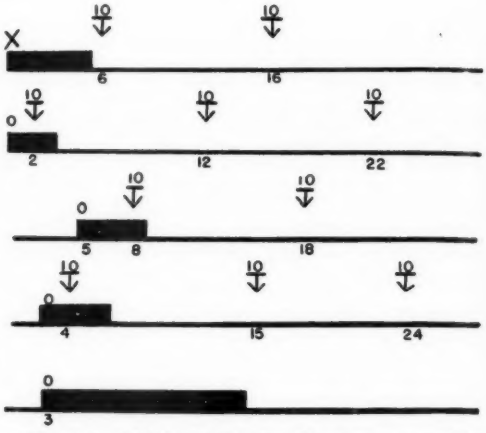

Chart 6. J.V.M.—M.T. In this chart a carefully planned schedule of 10 injections of 10 milligrams over a period of 4 months produced 4 consecutive painless flows. The first injection was given on the 6th day of the cycle and thereafter repeated at 10 or 14 day intervals. The 14 day intervals were planned in order to allow painless withdrawal bleeding to occur approximately once a month. In this way it was hoped to avoid excessive stimulation of the endometrium (see Chart 5). However, the 4th consecutive anovulatory flow was abnormally prolonged. To avoid this, treatment should probably be limited to 3 consecutive months only in planning a series of injections.

tively given for more than 3 months—even though withdrawal bleeding has taken place at intervals—there is a tendency for hyperplasia to develop as shown by prolongation of the last anovulatory flows (Chart 6). It may prove wise, therefore, if this treatment is to be kept up to advise consecutive injections for 3 months only out of 4, assuring the patient that relief from pain may be obtained for 9 months of the year, but that the 3 untreated periods between consecutive courses may be just as painful as those before treatment was started.

4. Further evidence that elimination of cramps after estrogen is associated with suppression of ovulation. We believe that functional dysmenorrhea as a clinical entity occurs only as a sequela of ovulation, and also that complete absence of cramps following estrogen therapy constitutes good evidence that ovulation has been temporarily suppressed. This was first suggested by the series of endometrial biopsies after treatment with estradiol benzoate already mentioned, showing absence of the usual secretory pattern when the menses was rendered painless by the medication. When biopsies were taken before bleeding in the present series, they showed that estradiol diproprionate similarly prevented the formation of a secretory endometrium when cramps were eliminated. Thus, in Chart 4, a biopsy on the day before a painless flow, 14 days after the last medication, showed a proliferative endometrium, the effect of estrogen only.

It is recognized that evidence from biopsy alone can be reasonably attacked on the basis that the

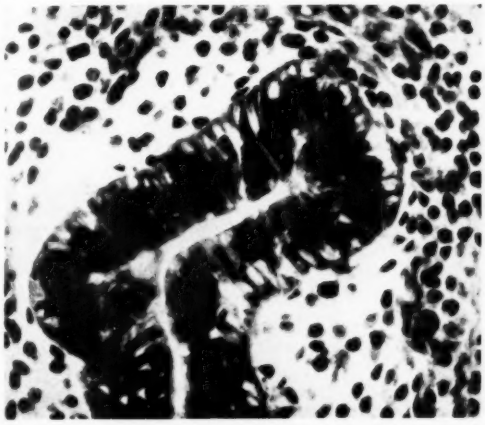

Fig. 1. J.V.M.—M.G. Endometrial biopsy taken on the 34th day of the cycle, 28 days after an injection of 10 milligrams of estradiol diproprionate in a patient with previously regular painful menses. The epithelial glands show central nuclei, subnuclear vacuoles. The stroma is edematous. This biopsy shows changes that occur very soon after ovulation, the early effect of the corpus luteum hormone.

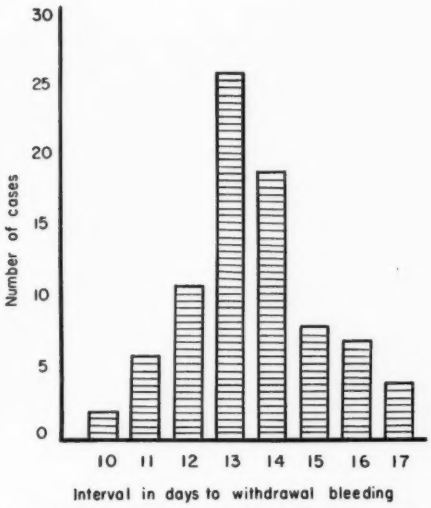

Chart 8. In 88 cases the number of days after an injection of 10 milligrams of estradiol diproprionate to onset of painless withdrawal bleeding varied from 10 to 17, with the mean for the group at 13 days.

usual secretory pattern may have been overwhelmed or otherwise repressed by the large dosage of estrogen employed, and that absence of secretion in the endometrium cannot constitute proof of the suppression of ovulation.

The results of treatment in the present series, however, bring out other effects for which we can conceive of no other rational explanation than that ovulation has been suppressed by the estrogen given.

The first additional evidence for the thesis that ovulation is suppressed was discussed in the second preceding paragraph. Here it was reasoned that the ability to produce an amenorrhea of any desired duration with repetition of the dose of estrogen here used could be explained only on the basis of temporary repression of follicular development.

Second, attention may again be called to an effect noted in the previous paper on the use of stilbestrol in essential dysmenorrhea (1). It was pointed out that these patients as a group showed unusually regular cycles before treatment. They were given 2 to 3 weeks of medication. Painless bleeding generally occurred 1 week later, but in 24 per cent of that series, no such bleeding appeared and instead there was an interval of over 1 month of amenorrhea after the last dose, terminated by menses with typical cramps. It seems illogical to suppose that this amenorrhea totalling 6 to 7 weeks, in patients previously regular, should occur on the basis of a chance irregularity alone as often as 24 per cent of the times treatment was given. Some other explanation than mere coincidence appears necessary. Many other patients showed only a scant spotting a week after the last medication, but it is significant that a crampy menses invariably occurred in the whole group about 1 month after treatment was concluded. The constant occurrence of this monthly interval, consistent with the individual's regular cycle, lends support to our contention that the normal pituitary—ovarian cycle is repressed until cessation of the estrogen. It is then easily understood that variability in the amount of painless bleeding directly after treatment—from none at all to slight menorrhagia—is merely a measure of the response of the individual endometrium to the character of stimulation given.

Similar reasoning can be applied to the variation in the amount of bleeding after estradiol diproprionate (occasionally there was no bleeding at all directly after treatment; at other times it varied from a scant spotting to a rather profuse flow). A consistent interval, however, from the last injection to the next crampy flow almost invariably obtains, whether or not a painless "withdrawal bleeding" occurs in the meantime. This interval is longer than the patient's usual cycle length. It is prolonged by the amount of

time that the last injection effectively inhibits the pituitary. In the present series the interval from an injection of 10 milligrams to the next typical dysmenorrhea, if no more medication was given, varied from individual to individual, with a range of from 36 to 46 days for the group (Chart 2).

One case in the present series deserves special mention. In a 26 year old girl with regular, painful periods, one injection of 10 milligrams of the diproprionate was given on the 6th day of the cycle. On the 34th day of the same cycle, when the patient was approximately 1 week overdue, endometrial biopsy and laparotomy were performed. The endometrium was early secretory in type, showing well marked subnuclear vacuoles in the epithelial glands (Fig. 1). Fresh blood was found in the pelvis and a very recent corpus hemorrhagicum demonstrated in an ovary. These findings strongly suggest that ovulation had occurred not more than 2 or 3 days previous to the operation on the 34th day (Chart 7). They confirm the postulates here presented to explain the cases of 5 or 6 weeks' amenorrhea not infrequently encountered, and constitute incontrovertible evidence that in this case the injection of estrogen delayed or temporarily suppressed ovulation.

In view of the facts presented, we believe that sufficient evidence has been accumulated to conclude that if an adequate dose of estrogen is given early enough in the cycle, ovulation will be temporarily suppressed; the true ovarian cycle will not start until the effect of the dose has worn out and released the pituitary to produce follicle stimulating hormone. Then, and not until then, will a follicle develop to maturity and finally ovulate, and the result in these patients will be the return of typical dysmenorrhea consistently about 1 month after pituitary release.

SUMMARY

Previous work on the treatment of essential dysmenorrhea with estradiol benzoate and stilbestrol is summarized. The results of over 260 injections of estradiol diproprionate in 33 patients with this complaint are discussed in the light of the previous experience. Examples of charts from actual case records are presented to demonstrate not only successful treatment, but also the pitfalls of this type of therapy. The previous contention that cramps are eliminated temporarily by suppression of ovulation is supported by further evidence from the present series.

CONCLUSIONS

1. The cramps of essential dysmenorrhea can be successfully eliminated with estrogen when an adequate dose is started early enough in the cycle to suppress the pituitary, hence ovulation; this suppression is maintained until the effect of a given dose has worn off. After conclusion of treatment a normal cycle invariably recurs with the usual dysmenorrhea.

2. This effect can be obtained as well with estradiol diproprionate as with estradiol benzoate or oral stilbestrol. The advantages of using the former are that a minimum of injections are required and there are no demonstrable toxic effects.

3. To obtain the desired result with estradiol diproprionate, an injection of 10 milligrams must be started by the 6th day after onset of menses. This dose is repeated in groups of 3 injections at 10 day intervals, except that every third injection should be given after a 14 day interval to allow a painless withdrawal bleeding to take place approximately once a month.

4. Estrogenic treatment according to the schedule given should probably be limited to 3 consecutive months, a painful ovulatory menses being allowed to occur every 4th month before therapy is resumed.

5. This treatment is effective as a temporary method of relief only; it does not constitute a cure for essential dysmenorrhea.

REFERENCES

1. Sturgis, S. H. N. England J. M., 1942, 226: 371–376.
2. Sturgis, S. H., and Albright, F. Endocrinology, 1940, 46: 68–72.

THE ANGIOCARDIOGRAPHIC DEMONSTRATION OF AN ARTERIOVENOUS FISTULA

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THE roentgen demonstration of peripheral arteriovenous fistulas has been accomplished by the introduction of radio-opaque substances through direct arterial punctures (1, 2, 3, 6, 7, 8). Both thorotrast and diodrast have been used. Direct puncture is limited to those vessels which are easily accessible. The femoral, brachial, and radial arteries have been most commonly utilized for this purpose. When the involved vessels are deeply situated, direct arterial puncture is not feasible; and surgical exposures of the artery proximal to the fistula must be performed in order to introduce the opaque substance safely and successfully. Gross (4, 5) has obtained successful intracranial angiograms of arteriovenous aneurysms of the circle of Willis by injecting diodrast 50 per cent directly into the common carotid artery exposed through a cervical incision. A similar technique might be utilized for such deep intrathoracic vessels as the innominate and subclavian arteries. However, this involves a formidable surgical procedure and may be especially difficult in the presence of the increased vascularity associated with the arteriovenous communication. A much simpler method is available through the application of the angiocardiographic technique. This consists of the rapid introduction of diodrast 70 per cent through a special needle (Robb and Steinberg) into an antecubital vein making serial roentgen exposures which may be recorded either fluorographically or roentgenographically (10, 11).

CASE REPORT

No. 461436. D.B., a 13 year old girl, suffered a severe trauma to the head at the age of 4 when she was hit by a towing truck crane. At that time roentgenograms were made and failed to reveal a fracture. Following the accident the child's mother noted enlarged veins in the left arm. These increased in size. Mental development was definitely retarded. Four years previously school physicians had advised hospitalization for study and treatment of the vascular disorder. Studies were made but no treatment was instituted. Patient had no local or general symptoms aside from slight breathlessness upon exertion. She entered Mount Sinai Hospital on May 4, 1940, for investigation.

Physical examination revealed a well nourished and moderately well developed girl of 13 with definite mental retardation (Binet, 9 years). The left side of neck and supraclavicular fossa showed definite expansile systolic pulsation; a marked thrill and bruit were present over this site. Compression of the subclavian vessels by means of pressure over the supraclavicular region abolished these and the resting pulse of 95 per minute dropped sharply to 52 per minute. Pressure over the axillary artery produced neither of these effects. Measurements of the upper extremities showed the left to be definitely larger than the right. Skin temperature was 2 degrees C. higher on the left side. The superficial veins of the entire left extremity were very much dilated and pulsated in systole. The left radial pulse was weaker than the right. Blood pressure was 96/30 in right arm; 128/60 in left arm. The retromanubrial dullness was enlarged to the left. There were many dilated superficial vessels over the chest. An enlarged tortuous pulsating artery was felt over the left shoulder anteriorly. The heart was enlarged to the left—apex percussed to anterior axillary line in 5th intercostal space. A thrill was felt over midclavicular region but not over heart. At apex a systolic murmur was heard. $P_2 > A_2$, rhythm was regular.

Laboratory data: Venous pressure was 12.2 centimeters (right arm). Following pressure on right upper quadrant—13.4 centimeters. Circulation time was 12 seconds (saccharine). Oscillometric readings were right arm, 3; left, 20+; right forearm, 2; left, 8; right leg, 2; left 2. Wassermann test showed negative reaction. Total blood volume was 3438 cubic centimeters; red cell volume, 36 per cent; volume per kilogram, 112 cubic centimeters; hemoglobin, 110 per cent (Sahle).

Roentgenograms of the chest revealed a considerable degree of enlargement of the heart, particularly the right side. The superior mediastinum was widened. This later proved to be due to a markedly dilated superior vena cava, demonstrated angiocardiographically.

Roentgenogram of the left humerus showed the entire shaft of this bone to be replaced by an irregular vacuolization present both in the cortex and medulla. This was later shown pathologically to represent vascular channels which had completely replaced the normal bone marrow.

Electrocardiogram showed regular sinus rhythm, rate 95; left axis deviation; PR, 0.22 seconds. Compression of subclavian vessels slowed heart to 52 per minute.

Phonocardiogram showed: First sound normal, followed by prominent high pitched systolic murmur, loudest at Erb's area. This was recorded also in left axilla. An auricular and third heart sound are present at apex.

A clinical diagnosis of arteriovenous fistula of the left subclavian artery was made. Because the bruit disappeared upon pressure over the subclavian vessels while similar pressure over the axillary vessels produced no such effect, it seemed most probable that the site of the fistula was between the subclavian vessels. The etiology was undetermined. It was suggested by some that it might be congenital. However, in view of the history of a severe

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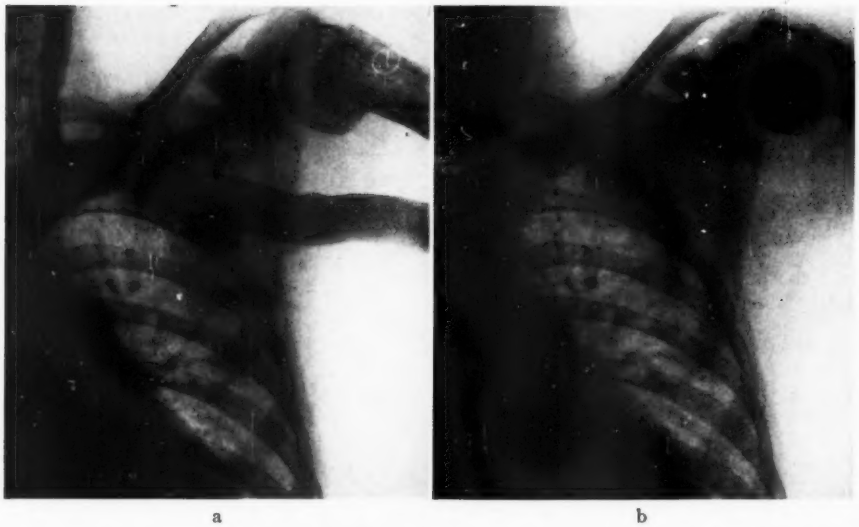

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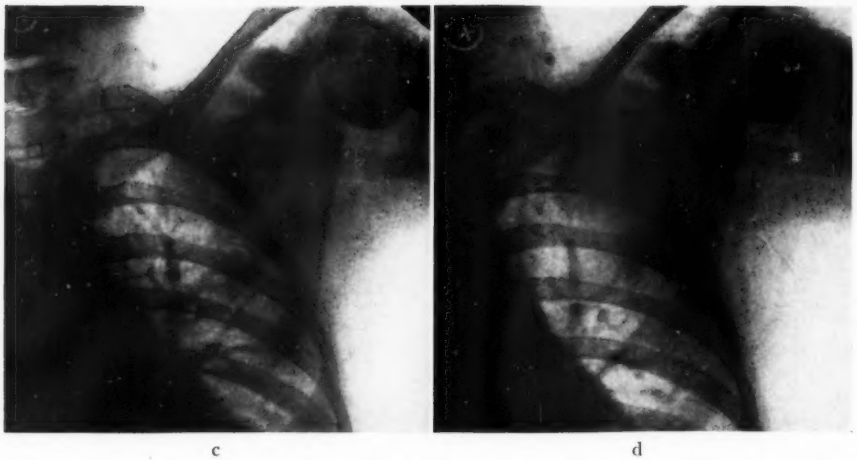

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Fig. 1. Injection of antecubital vein on involved side, left. a, Film taken during the injection. Dilated axillary, subclavian and innominate veins on the left side are visualized. Retrograde opacification of left internal jugular and suprascapular veins. b, Film taken 3 seconds after beginning of injection. The veins have emptied. The aorta is opacified. c, Film taken 5 seconds after beginning of injection. The axillary and brachial arteries are now visualized, the opaque substance having entered the systemic circulation from the heart. The subclavian artery is not seen. d, Film taken 7 seconds after beginning of injection. The axillary artery and vein are both opacified. There is also visualization of interlacing vascular channels to the head of the humerus.

trauma to left side of head at age of 4, it was felt by others that it had most likely been acquired at that time.

Although the clinical picture was unmistakably that of an arteriovenous fistula, more accurate localization of its site was considered highly desirable before operative intervention. The surgical approach for a fistula between the subclavian vessels would be transthoracic while that for a fistula between the axillary vessels would be entirely extrathoracic. In order to determine the site of the fistula, therefore, angiocardiography was performed.

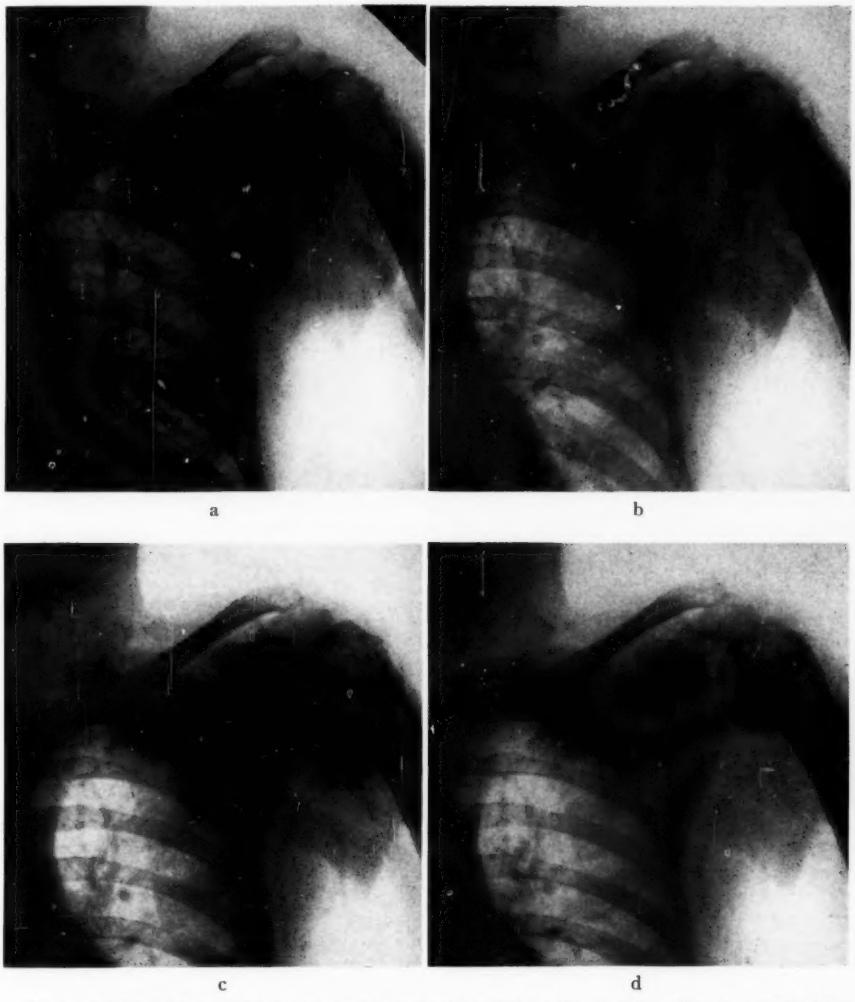

Fig. 2. Injection of antecubital vein on the uninvolved side, right. a, Film taken 6 seconds after beginning of injection. The left axillary artery and branches to the head of the humerus are visualized, the opaque substance having reached the systemic circulation after traversing the heart and lungs. b, Film taken 7 seconds after beginning of injection. The dilated left axillary vein is shown caudad to the artery. The tortuous channels extending into the head of the humerus are seen. c, Film taken 8 seconds after beginning of injection. The left axillary vein is still visualized while the left axillary artery is fading. d, Film taken 9 seconds after beginning of injection. The artery is no longer opacified. The tortuous channels to the head of the humerus are still visible.

Two injections of 30 cubic centimeters of diodrast 70 per cent were given; the first into the left antecubital vein, the second into the right antecubital vein. Roentgenograms were taken rapidly with the x-ray tube centered over left supraclavicular region, shoulder, and upper arm.

Injection of the left antecubital vein, involved side (Fig. 1), definitely established the identity and size of the left axillary, subclavian and innominate veins and the axillary artery. It was evident that the opaque material must have reached the axillary vein directly from the axil-

Fig. 3. Roentgenogram of the chest revealed considerable degree of enlargement of the heart, particularly the right side. The superior mediastinum was widened. This later proved to be due to a markedly dilated superior vena cava, demonstrated angiocardiographically.

lary artery at a point near their origins, since both of these vessels were simultaneously visualized. It was likely that the actual fistula was present at a point proximal to the origin of the axillary vessels. The third portion of the subclavian artery was, therefore, designated at the probable site of the fistula.

Injection of the antecubital vein was also made on the uninvolved side, right (Fig. 2). Revisualization of the axillary veins without doubt signified the existence of a fistulous communication at or above the origin of the axillary vessels.

Subsequent operative findings confirmed the angiocardiographic localization of the fistula. A preliminary double ligation of the left axillary artery and vein was done but this resulted in no essential change in the clinical picture. The bruit persisted above the point of ligation and the heart size remained unchanged. An exploration of the proximal portion of the axillary artery at its origin revealed an arteriovenous fistula which was only partially excised. Complete obliteration of the fistula, however, was impossible at this time, since its major portion involved the subclavian vessels. A later exploration of the third portion of the left subclavian artery was unsuccessful due to the enormous collateral circulation present in this

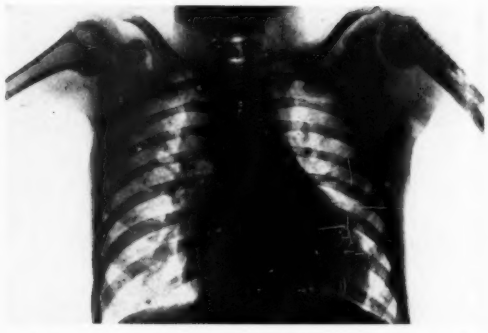

Fig. 4. Roentgenogram of the left humerus showed the entire shaft of this bone to be replaced by an irregular vacuolization present both in the cortex and medulla. This was later shown pathologically to represent vascular channels which had completely replaced the normal bone marrow.

region. Finally, because of increasing cardiac failure, ligation of the first portion of the left subclavian artery was performed through a transthoracic, transpleural approach (12). This resulted in complete disappearance of all bruits and murmurs. The cardiac status eventually returned to normal. After operation a gangrenous involvement of the left wrist and hand due to impaired circulation necessitated a partial amputation of that extremity.

SUMMARY

1. Angiocardiography is a simple, effective procedure for the precise localization of arteriovenous fistulas involving large vessels near heart.

2. It is especially valuable in cases involving those vessels which otherwise would require a difficult surgical exposure to perform arteriography.

REFERENCES

1. Allen, E. V., and Camp, J. D. Radiology, 1934, 22: 678.
2. Idem. J. Am. M. Ass., 1935, 104: 618.
3. Bird, C. E. J. Am. M. Ass., 1937, 109: 1626.
4. Gross, Sidney W. Arch. Neur. Psychiat. Chic., 1941, 46: 704.
5. Idem. Radiology, 1941, 37: 487.
6. Horton, B. T. Proc. Mayo Clin., 1933, 8: 189.
7. Horton, B. T., and Chormley, R. K. Proc. Mayo Clin., 1933, 8: 773.
8. Idem. Surg., Gyn. Obst., 1935, 60: 978.
9. Robb, G. P., and Steinberg, Israel. J. Clin. Invest., 1938, 17: 507.
10. Sussman, M. L., Steinberg, M. F., and Grishman, A. Am. J. Roentg. 1941, 46: 745–747.
11. Idem. Radiology, 1942, 38: 232–233.
12. Touroff, A. S. W. Surgery, 1941, 10: 747.

FRACTURES OF THE HUMERAL CONDYLES IN CHILDREN

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DESPITE the fact that a serviceable elbow seems to be recovered in most fractures of the humeral condyles in children, the surgeon cannot feel entirely satisfied with the treatment of these injuries. Under conservative treatment, which fails to ensure an accurate reduction, a successful outcome depends to a great extent upon the reparative power in the child. Admittedly this is not good fracture treatment. Under operative treatment, which makes possible an exact anatomical replacement of the fragment, more satisfactory results are obtained, and hence open intervention is the accepted method of treatment. Yet in the roentgenograms of the apparently accurately reduced fractures with excellent function, structural irregularities are seen which bring into question the efficacy of the treatment.

With a view to studying the end-results of the condylar fractures that have been treated or seen in our clinic, a series of 54 cases was compiled, on 32 of which it was possible to obtain a final report. The posttreatment period extended in several instances over more than 22 years. Of particular interest were the roentgenographic findings at the time of the final examination.

ANALYSIS OF CASES

In the series of 32 cases there are 13 fractures of the lateral condyle, 16 fractures of the medial epicondyle, 2 of the less common fractures of the internal condyle, and 1 of the rare fractures of the lateral epicondyle. The group includes fresh fractures that were treated at the time of the injury and fractures of long standing that came to our attention because of impaired use, pain, or deformity.

Fractures of the lateral condyle, 13 cases. The ages of the patients ranged from 2 to 17 years. Six fractures had been treated conservatively, 5 of them by physicians outside of our clinic and 1 by the writer. Five of the patients, when an examination was made from 2 to 22 years after the injury, had good serviceable use of the elbow; in 3 cases the motion was practically normal, and in 2 cases there was only a slight limitation of motion and a slight change in the carrying angle of the arm. In the sixth case, when the examination was made 35 years after the injury, flexion was limited to about 50 degrees, extension to about 130 degrees, and both supination and pronation were restricted.

Of interest in connection with the 5 cases that had been treated conservatively outside our clinic was the variance in the amount of function when the writer first examined the patient, and later when the elbow was checked for this report. The 5 cases were first seen after a lapse of from 7 weeks to 13 years from the time of the fracture. In only 1 of these cases was the motion normal, and in the 4 other cases the function was limited and the elbow distorted. Yet when these 4 elbows were again examined, from 3 to 22 years after the initial injury, 3 had normal motion. Other observers have noted that although motion is restricted for a time after the fracture, the patient may eventually recover almost complete function of the joint (Fig. 1).

Operative reduction had been carried out in 6 cases, 4 of which were fresh fractures and 2 of a month's duration. In 4 cases, upon examination of the elbow from 2 to 15 years after the fracture, the motion was perfect. In 1 case, when the end-result was checked 26 years after the fracture, the motion in flexion was limited 15 degrees and there was a cubitus valgus deformity of 15 degrees. In the sixth case, upon examination of the elbow 25 years after the operation, extension was limited to 140 degrees and flexion to 40 degrees.

In 1 case of a fracture of the lateral condyle, the fragment had been excised 11 days after an unsuccessful attempt at manipulation. The result was unsatisfactory, the patient having limited extension and flexion of the joint.

To summarize the results in fractures of the lateral condyles: Under conservative care 5 of 6 patients recovered satisfactory motion of the elbow joint; under operative treatment 4 of 6 patients recovered perfect function and 2 had slightly limited motion. In 1 case that had been treated by manipulation there was a restriction of all motions, and in 1 case in which the fragment had been excised there was a fairly marked limitation of motion. It is evident that equally good results seemed to be obtained from conservative and operative treatment of the fracture.

Whereas there was little difference in the clinical results under closed or open treatment, there was a contrast in the end-result roentgenograms of the

From the MacAusland Orthopedic Clinic.

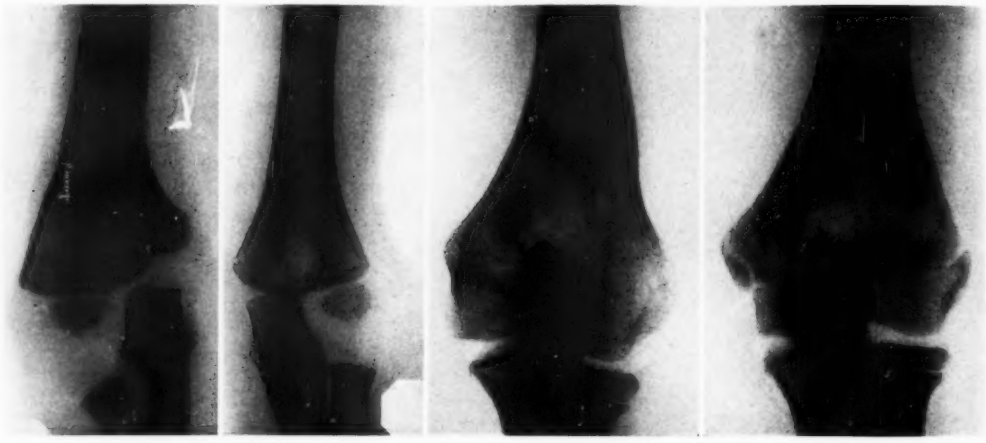

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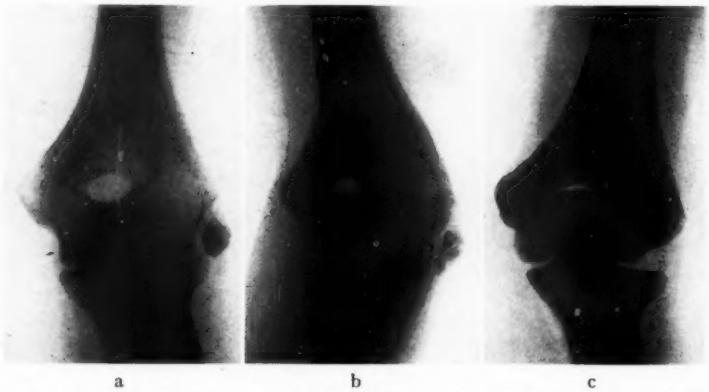
Fig. 1. a, Malunion in a fracture of the external condyle of the left humerus 1 year after conservative treatment. Patient had restricted motion and a cubitus varus deformity. b, ten years after the fracture, showing the normal appearance of the external condyle. Patient recovered practically normal motion.

two groups. In general the roentgenograms of the fractures that had been treated conservatively showed malunion and an overgrowth of the condyle. On the other hand, the roentgenograms of fresh fractures that had been treated operatively showed a well developed and accurately replaced condyle.

Fractures of the medial epicondyle, 16 cases. The ages of the patients ranged from 6 to 17 years. Six fractures had been treated by conservative reduction, 4 of them by physicians outside of our clinic. When these 4 elbows were examined after a lapse of 6, 10, 12, and 13 years, respectively, only 1 had normal motion. Extension was limited in 2 cases, and both extension and flexion were restricted in the fourth case. One of the patients had an ulnar neuritis, which was the only case of this complication in the series. Of the 2 cases handled conservatively at our clinic, 1 had been so treated 25 years previously, and 1 had been manipulated in recent years because the comminution of the fragment prohibited operative reduction. In both of these elbows a full range of motion was recovered.



a b c

Fig. 2. a, Displacement of the external epicondyle as the result of an injury in childhood. b, One month later, following treatment of the elbow in a plaster cast, showing proliferative tissue and absorption. c, Nineteen years later, the external condylar head is well shaped, even though the epicondyle is missing.

a b

Fig. 3. a, Fracture of the external condyle of the left humerus. b, Well developed external condyle 2 years after operative reduction.

Seven fractures had been reduced operatively, 5 of them immediately after the injury, 1 within a period of 2 weeks, and 1 after the lapse of a year. All the elbows that had been reduced promptly were found to have good function when examined from 1½ to 10 years after the fracture. Both elbows reduced late were limited in motion, and 1 patient had an increased carrying angle.

Excision of the epicondyle had been carried out in 3 cases, 1 of which was a fresh fracture with a small fragment, and 2 of which were of long standing. Excellent results were obtained in all 3 cases.

To summarize the results in fractures of the medial epicondyle: Operative treatment in fresh fractures gave excellent results, the motion being complete and the carrying angle normal. By conservative treatment a complete range of motion was recovered in only 3 of 6 cases.

In the roentgenographic study of the end-results the feature that stood out prominently was the

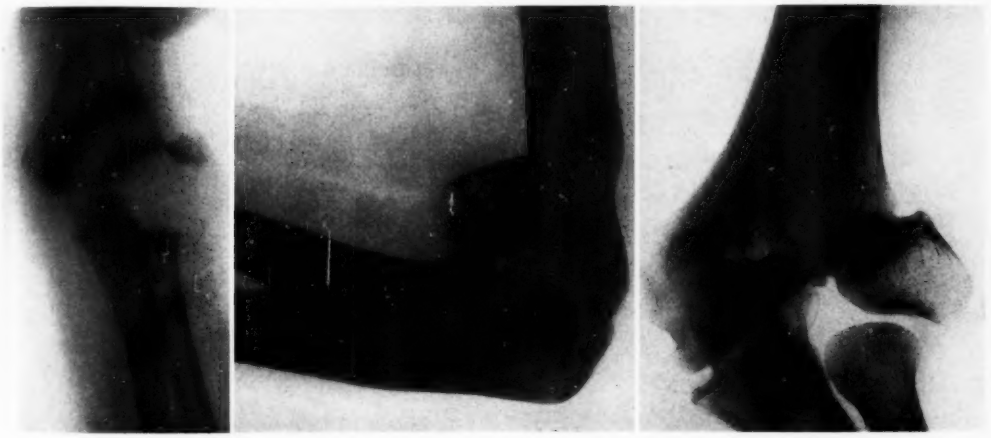


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Fig. 4. a, Displacement in a fracture of the external condyle 7 weeks after conservative treatment in acute flexion. b, The same fracture 17 years after the injury, showing the malposition, non-union, and enlargement of the condyle.

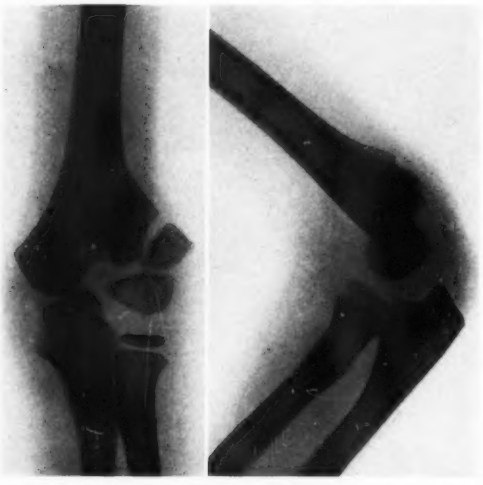

Fig. 5. End-result in a fracture of the external condyle 2 years after conservative treatment in acute flexion, showing non-union and squatting out of the condyle.

overgrowth of the fragment and the tendency of the epiphysis to be displaced forward and downward. These changes were evident in all cases whether they had been treated by manipulation or by operation. Irregularities in the contour of the external condyle were associated with several of these fractures.

Fractures of the medial condyle, 2 cases. Both cases had been treated by manipulation outside of our clinic. One patient, when examined 10 years after the fracture, had only a slight limitation of motion in the elbow. In the other case in which

Fig. 7. The accurate reduction possible by operative treatment.

Fig. 6. End-result in a fracture of the external condyle 4 years after conservative treatment in acute flexion, showing malunion and squatting out of the condyle. Note Nature's attempt to provide a serviceable joint by creating a new articular surface.

the fragment had been excised 1 month after an unsuccessful manipulation, limited flexion, extension, and pronation resulted. The patient, however, had no complaint and was able to climb ropes in his work without any trouble.

Fracture of the lateral epicondyle, 1 case. This patient was not seen until she was 27 years old, but she had had an injury of the elbow in childhood which apparently had not been treated. At the time of the examination the elbow was tender, painful, and limited in extension and flexion. The epicondyle had been pulled off, and the condylar area was infected (Figs. 2a and 2b). A plaster cast was applied and later a bone curetting was necessary. When the elbow was re-examined 19 years later, the patient had complete motion in the joint and there was solid healing (Fig. 2c).

DISCUSSION

As is generally true when condylar fractures are treated conservatively, satisfactory functional results were obtained by closed methods in many of the cases in this series. There is, however, some question as to whether the results of conservative handling are generally as satisfactory or as numerous as they are claimed to be. Condylar fractures occur in children, and they are followed through to an end-result in only relatively small series of cases such as is presented in this paper. How many fractures terminate in a distorted elbow with limited motion is not known.

Slight limitations of motion in the elbow are likely to be disregarded by both the patient and the physician, since the joint bears no weight and 90 per cent of its useful function lies within the range of 60 degrees of flexion and 130 degrees of extension. Particularly is this true when the rotary motion is preserved, as it is in condylar fractures. In the presence of a limitation in extension of from 10 to 15 degrees, disturbances of the carrying angle are not evident.

a b

Fig. 8. a, The enlarged and displaced medial epicondyles in 3 cases following conservative treatment in acute flexion, 10, 6, and 13 years previously. Note the lack of ossification in all cases and the proliferation of bone in the external condylar area in 1 case. b, The same enlargement and displacement of the medial epicondyle 3 years after operative reduction with suture of the fragment. Note the proliferation of bone in the external condylar area.

It is also possible that deformities give rise to no symptoms because the elbow in childhood is not called upon for heavy work. Only in later life when the elbow might be subject to heavy usage would the joint cause any difficulty. Unfortunately, in the series of cases reported little light was thrown on how the elbow would withstand strain, as none of the patients did heavy work, although most of them had reached adulthood at the time of the final examination.

The roentgenographic study of the end-results was interesting. In fractures of the external condyle that had been treated operatively, the roentgenograms showed a well developed condyle in good position (Fig. 3). Under conservative handling of the fracture an enlarged condyle with nonunion or malunion resulted (Figs. 4, 5, and 6). Figure 7 shows the accurate reduction possible by operative treatment and may be contrasted with Figure 5 showing the distorted elbow in a fracture that was treated conservatively. Figures 5 and 6

Fig. 9. Ossification of the medial epicondyle in a patient 12 years of age.

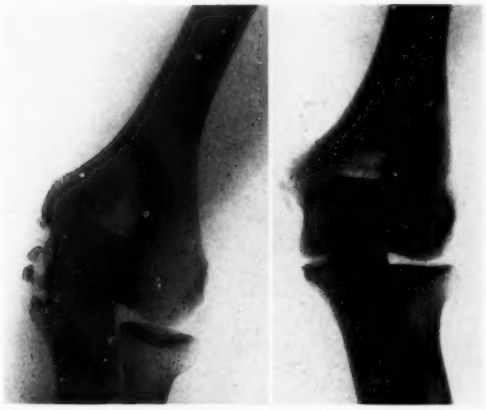

Fig. 10. a, left, Islands of bone suggesting regeneration following excision of the medial epicondyle 13 years previously. b, The same regeneration in a case treated by excision of the fragment 1½ years previously.

show clearly the nonunion, malunion, and squatting out of the condyle when the fracture is treated with the elbow in the position of acute flexion. The latter roentgenogram also illustrates well the effort on Nature's part to provide a serviceable joint in the presence of deformity.

Roentgenographic studies of the end-results in fractures of the medial epicondyle usually showed an enlarged fragment that had pulled away from its bed. These changes were observed in cases that had been treated either operatively or conservatively (Fig. 8). It is difficult to explain such findings in cases that have been reduced accurately. Either still better replacement of the fragment or more efficient immobilization may be necessary. The favorable time for operation may be questioned, it being possible that the operator should wait for the blood clot to be absorbed instead of reducing the fracture immediately.

The fact that such irregularities appear in the end-result roentgenograms of accurately reduced fractures of the medial epicondyle should be kept in mind in handling long-standing and neglected fractures that present a similar picture. Conservative treatment would seem to be preferable to operative excision of the fragment in such cases. If the fracture is recognized only after a superimposed injury, and the case happens to be one of litigation, a great deal of emphasis may be placed on the roentgenographic findings until it is pointed out that the same irregularities appear in the accurately reduced fractures.

The proliferative islands of bone that showed around the outer margins of the joint in fractures involving the medial epicondyle are probably due to the original injury and to the attempt to force the motion of the joint (Figs. 8a and 8b).

The failure of union between the medial epicondyle and the humeral shaft, which normally takes place about the 18th year of life, was noted in most cases (Fig. 8). There were 7 patients over nineteen years old and yet in only 1 case had the epicondyle joined the shaft (Fig. 9).

Of particular interest in the roentgenograms of 2 cases of operative excision of the medial epicondyle were islands of bone that suggested regeneration (Fig. 10). The possibility of such regeneration has been mentioned by Voshell and Taylor.[1]

Both clinical and roentgenographic findings point to the fact that operative intervention is the effective method of treatment in fractures of the external condyle. Open reduction is also the preferable method in fractures of the medial epicondyle, ensuring an accurate reduction, although the findings in the end-result roentgenograms cannot be explained. In the latter fracture, if conservative treatment must be considered because of contraindications to operative reduction, there would seem to be a better chance of obtaining a favorable result than under similar circumstances in fractures of the external condyle.

Operative reduction is a simple procedure. It is carried out immediately after the injury. The muscle attachments are pulled upward, and the fragments approximated. All soft tissue should be preserved.

The method of maintaining the position of the reduced fracture depends upon the nature of the pathology. The larger the fragment with its greater volume of muscle attachments, the heavier the fixation needed. The writer uses either chromic catgut sutures or a vitallium nail of small caliber in fresh cases, and a nail in cases of long standing. When necessary the nail may safely be driven through the epiphyseal plate.

The position in which the elbow is maintained during the healing process is governed by the pathology, but flexion of the joint to a right angle is preferable to full flexion. In order to relax the muscles, it is advisable, unless some form of internal fixation is used, to flex the wrist in fractures involving the medial epicondyle and to hyperextend the wrist when the external condyle is involved.

Following the reduction, the fracture should be allowed to heal solidly before motion is permitted. The practice of forcing the joint to obtain motion by such measures as carrying heavy weights cannot be condemned too strongly. In any type of fracture such procedure causes further damage to the joint. Provided there is no bony block to motion and no scar-tissue formation, motion will return upon the resumption of use.

[1]Voshell, A. F., and Taylor, K. P. A. J. Bone & Joint Surg., 1939, 21: 421.

SURGICAL TREATMENT OF PERIPHERAL ANEURYSM

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THE World War was a great stimulus to blood vessel surgery and this country's involvement in a second war of survival in our time makes the subject of surgery of aneurysm even more timely.

The definition of aneurysm as a blood filled sac communicating with an artery at once needs elucidation, because the multiple forms and sites at which it may occur in the human body, as well as the different causes, make this more a syndrome than a specific disease. It is apparent that the symptoms and treatment will vary greatly, depending on whether the lesion is near the aorta or in a terminal vessel. Efforts to classify and outline aneurysm are difficult, and under the aneurysm title in the *Quarterly Accumulative Index Medicus* may be found an average of 24 subheads in the volumes of the last 5 years. In order to simplify this discussion, peripheral aneurysm will be divided into the two types interesting to us surgically, the arteriovenous aneurysm, in which there is a communication between the artery and the vein either directly or through a dilated vascular mass, and the aneurysm involving only the artery itself. Aneurysms of the heart, aorta, and skull are not included in this discussion. While our subject is treatment, classification of various types of aneurysm will be discussed briefly. Peripheral aneurysms may be arteriovenous or arterial and either one may be congenital or acquired as the result of trauma or degenerative disease.

Such adjectives as cirsoid, dissecting, idiopathic, traction, and diffused but add to the confusion; anatomical and pathological differentiations, due to the site or the true or false walls, need to be considered only in the light of their effect on treatment. Gunshot and stab wounds, as well as airplane and automobile accidents, are the most frequent causes of acquired aneurysms.

Arteriovenous Aneurysm

Acquired Arteriovenous Aneurysm

The acquired arteriovenous fistula is most often single, frequently a direct opening, and is seen fairly frequently in surgical practice. William Hunter was the first to describe it, and while in 1920 Callender had found only 444 cases in the literature up to that time, this number has more than tripled since. Symptoms vary with the site and extent of the fistulous opening. Experimental data have convincingly shown that certain physiological changes occur when a fistula develops. The immediate changes are:(1) a fall in general arterial pressure with a gradual recovery, the systolic pressure being equal or higher and the diastolic lower—thus a greater pulse pressure; (2) an increase in pulse rate; (3) an increase in venous pressure; (4) an increase in the cardiac output, depending on the size and location of the fistula; (5) a very temporary decrease in the size of the heart and the artery proximal to the fistula, due to the blood flow in the large venous system, followed by a gradual dilatation of the heart, artery, and vein proximal to the fistula, with hypertrophy of the heart; (6) gradual increase in the total volume of the blood; (7)development of collateral circulation around the fistulous site.

These points must be kept in mind in the consideration of the therapy. If the arteriovenous fistula is large, it must be repaired or definite, permanent damage to the heart will result. The symptoms in the acquired type are usually so apparent that the diagnosis is evident. The scar at the site of injury, followed by an enlargement of the part, increased temperature, the dilatation of the veins of that extremity, together with the bruit at the site of communication is confirmatory. An arteriogram will determine the extent of pathology present and occasionally other anastomoses are revealed by this method. Pressure over the site of the fistula will cause a decreased pulse rate—the Paré sign. An analysis of the blood in the tributary veins shows a higher oxygen content than in other veins. Pain is an inconstant sign but in the large ones usually develops with pressure on nerves or other sensitive parts. All of the symptoms accompanying a reversed flow in veins may occur, such as pigmentation, ulceration, dermatitis, hemorrhage, and gangrene.

Pathology. The endothelium soon lines the connection and coagulated blood in the sac is not unusual. The arterial pressure drives the venous blood back during systole, while in diastole venous blood may actually enter the artery. This mixture of venous and arterial blood causes venous stasis. The arterial blood returns directly through

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Fig. 1. Arteriogram of congenital arteriovenous fistula involving the ulnar artery. There are 11 aneurysmal connections present. The entire artery was eventually removed.

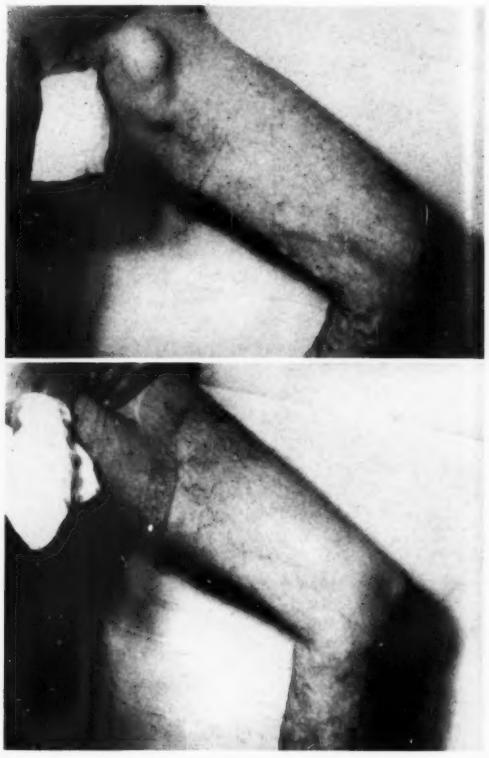


Fig. 2. a, above, Large aneurysmal varix connecting to the femoral bulb, fed by several small arteries. b, Manual reduction of same aneurysm.

the venous channels, frequently without being carried through the capillaries, and starvation of the periphery may occur with trophic changes.

Surgical treatment. It is wise to postpone operation until 4 to 6 months after the development of the fistula to permit the sudden physiological changes accompanying the fistula to have reached a level and, more important, to permit collateral circulation to become adequate. At the time of the repair, the physiological changes previously mentioned must be considered, as the closure of the fistula causes an exact reverse of all the processes mentioned. If the fistula has been present for a long time, it may be necessary first to decrease the total blood volume by phlebotomy to prevent overstrain of the cardiovascular system. Operation is best performed without the use of a tourniquet and no one operative procedure is applicable for each type of fistula. Theoretically, the ideal treatment would be one in which the fistulous communication could be closed and the continuity of the involved vessels re-established. This is rarely possible. The site of anastomosis should be exposed and explored. Temporary tapes above and below the fistula should be applied. If collateral circulation is adequate, the closing of the upper tape will not result in circulatory failure distally, and this effect can be observed at this time. The type of operation which is to be selected may be one of the following presented:

1. Repair of the fistula in the arterial wall through the opened and sacrificed vein. Suture materials should be of the finest arterial silk on nontraumatizing, minute, round needles, such as are used in eye surgery. These sutures should not enter the intima. A section of nearby fascia or muscle makes a better re-enforcement than the fistulous sac or vein. The ligation of the vein in these instances appears to be of therapeutic value, compensating for the reduced arterial supply by decreasing the rapidity of the blood return.

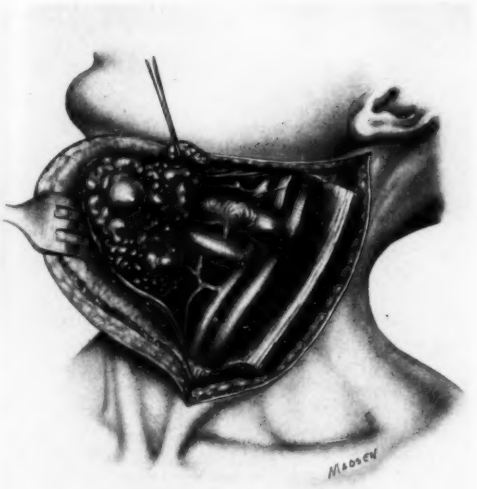


Fig. 3. Large arteriovenous fistula of the neck. First stage excision of left superior thyroid, lingual, and external maxillary arteries and facial vein.

Fig. 4. Same patient as Figure 3. Second stage excision of entire mass and right external carotid artery and its branches *en masse*, with cure.

2. Ligation, proximally and distally, of the artery and the vein with excision of the intervening fistula and vessels is frequently the treatment of choice when collaterals are adequate. In this type of treatment the intervening vessels must be removed or the fistula may recur. This operation is used most often in the upper extremity, head, or neck.

3. In some cases it is impossible to remove the fistula because of possible damage to secondary circulation. Quadrilateral ligation is then performed. The fistulous tract is opened and the clots evacuated; all openings into the fistulous tract are closed by fine arterial sutures and the sac is obliterated by imbrication and plication, as in the Matas endoaneurysmorrhaphy operation, or implant of muscle. The use of this operative principle has saved many limbs which in previous years it has been necessary to sacrifice.

CONGENITAL ARTERIOVENOUS FISTULA

The etiology of congenital arteriovenous communications is still under investigation. Arteries and veins normally anastomose in man in only the hands, feet, and the sexual organs, as shown by Hoyer, Krogh, and others. In studying the embryological rests frequently demonstrated in the newborn, it is not difficult to conceive of the same failure of closure in the arteriovenous system. These communications are usually multiple. They may occur in any part of the body but are

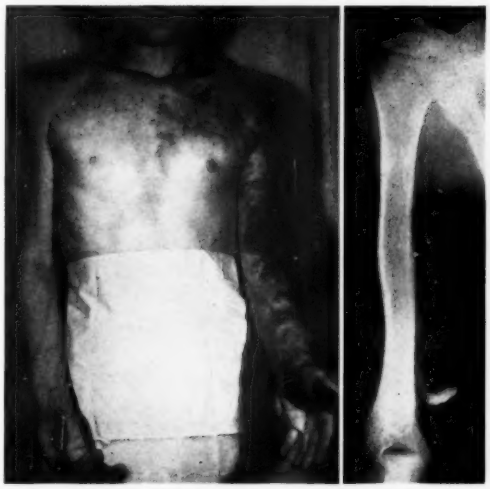


Fig. 5, left. Congenital arteriovenous fistula. Entire upper extremity, shoulder, and chest, with invasion of brachial plexus. Some blood vessel tumors have the characteristics of malignant neoplasms.

Fig. 6. Roentgenogram of arterial aneurysm of the brachial artery following gunshot. Aneurysm began to grow when slightly traumatized 20 years after injury. Doubled size in 1 month. Treatment: obliteration with cure. Note calcification.

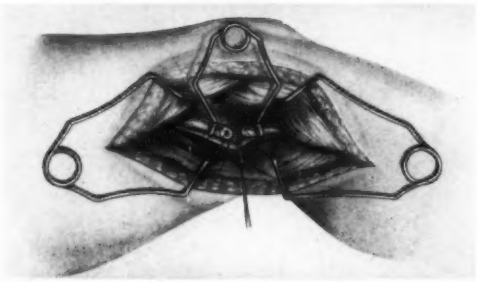


Fig. 7. End-to-end arterial suture with fine arterial silk. Adaptation of Farr retractor approximates arterial ends without trauma. Suturing completed without entering intima.

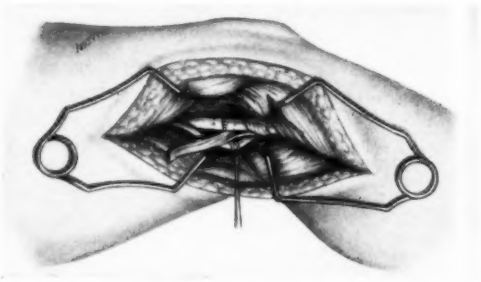
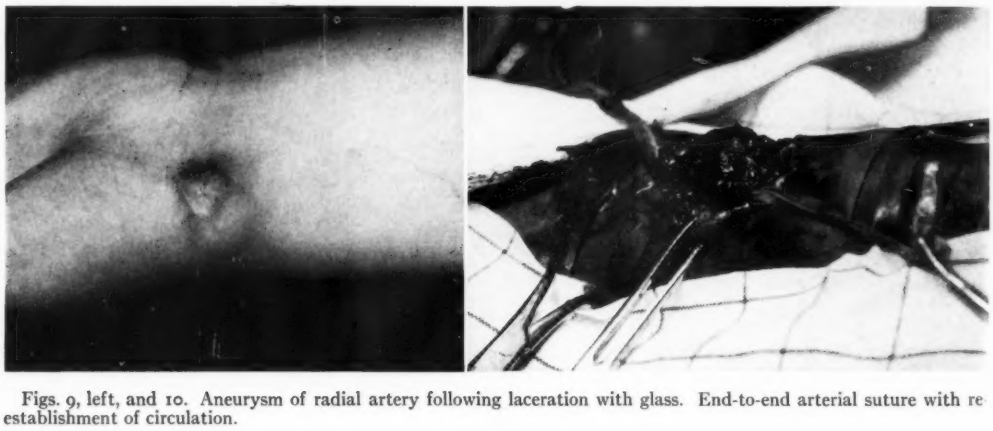


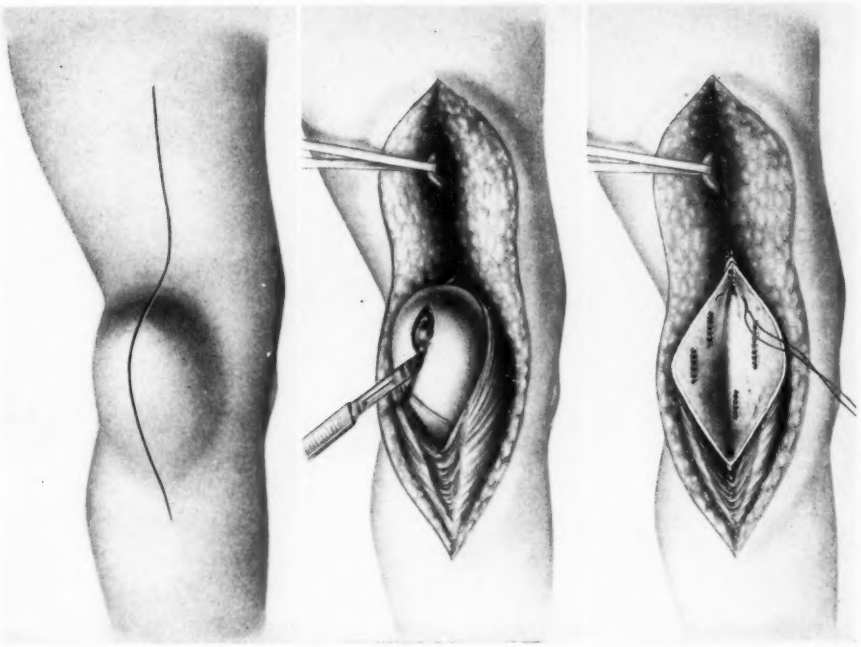
Fig. 8. Completion of suturing and re-enforcement of anastomosis with contiguous muscle flap.

particularly frequent in the upper extremities (Fig. 1). Many times, especially in the lower limbs, they are diagnosed as varicose veins and the usual history is that the abnormality was noticed at 3 to 5 years of age, but that the physician consulted advised that nothing be done as the patient "might grow out of it." Another form of arteriovenous connection is the so called aneurysmal varix, in which enlarged varicose veins connect with an artery (Fig. 2). This is not a rare lesion. It is frequently diagnosed and treated as varicose vein with resulting technical complications. The symptoms in the congenital type vary with the number, size, duration, and position of the communications. Minute ones may occur on the face, particularly around the eyes and mouth when the term pulsating hemangioma has been applied. The large ones are particularly frequent in the upper extremities. We have seen a congenital fistula in the neck in a patient of Dr. Irving S. Wright, in which a large mass of vessels in the suprahyoid muscle area was fed by the left lingual, external maxillary, and inferior thyroid arteries and so many abnormal connections from the right external carotid that the extirpation of all of those main branches of the left external carotid and the entire right external carotid artery was necessary to close the fistula (Figs. 3 and 4). The signs of *thrill* and *bruit* at the fistula site as well as arterial blood in the veins present a picture similar to that in the acquired type of fistula except for the fact that the congenital fistula is usually larger than the acquired one.

Treatment. In the small fistulas, particularly those on the face, extirpation frequently is sufficient to cure them. In selected instances a sclerosing solution judiciously introduced has eliminated the minute pulsating varix, and in a small number radium has been satisfactory. In undertaking the treatment of the large congenital connections, one finds that multiple and frequently heroic operative procedures may be necessary. The most important thing to remember is that the connections



Figs. 9, left, and 10. Aneurysm of radial artery following laceration with glass. End-to-end arterial suture with re establishment of circulation.



a b c

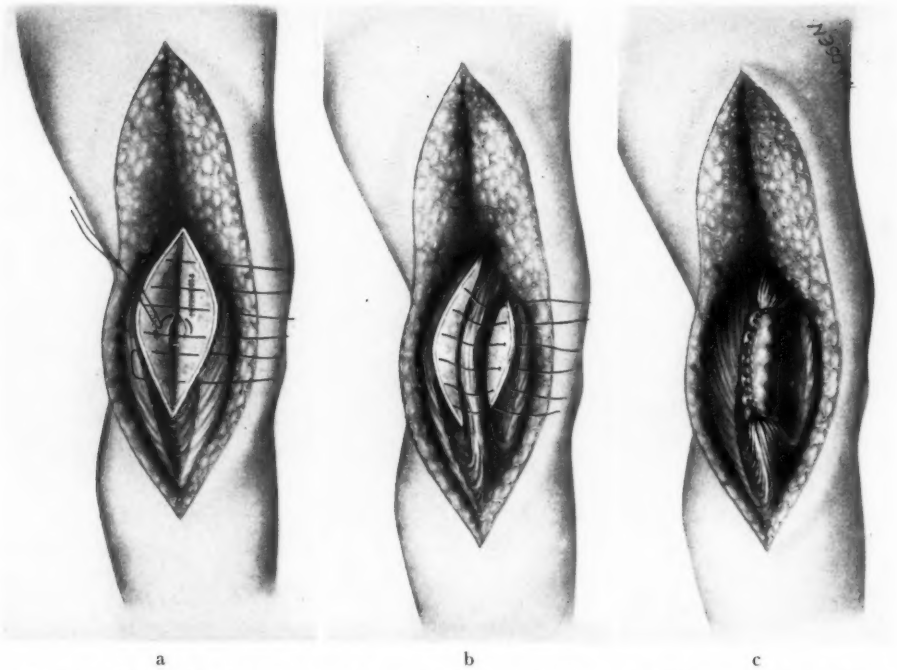
Fig. 11. a, Line of incision for a popliteal aneurysm. b, Control of circulation proximal to the aneurysm by tape and incision of aneurysm and evacuation of clots and débris. Note sural nerve which must be protected. b, Suturing of all collateral openings, ligation proximally and distally, and closure of artery aperture from within sac.

are usually multiple and the disheartening thing is that one may close 8 or 10 connections and have a recurrence due to the opening of another connection not patent at the first operation. It is our practice to operate on these patients without a tourniquet. The fistulous connection can then be localized with a sterile stethoscope. The extent of operative treatment is determined only by the pathological condition present, but one should not discontinue the operation until each fistulous opening and bruit have been eliminated. The site of the fistula should be exposed widely enough to permit control of normal vessels proximally and distally. The operation of choice in the large lesions is quadrilateral ligation and excision of the arteries and veins involved. At times one must remove vessels which appear necessary to the life of the part, but collateral circulation is present so frequently that most of these limbs will not be lost.

Some of the congenital communications act as newgrowths, invading all layers of tissue including bone. One of our most alarming problems arose from hemorrhage of the bone canal after an amputation for spontaneous gangrene in one of these growths. Matas has recently reported a case of this type in which there appeared to be metastasis. One of our patients showed similar characteristics (Fig. 5). In operating on a large and multiple arteriovenous fistula it must be remembered that while local relief is to be hoped for, the operation primarily is being done to prevent the cardiovascular failure which will eventually result. Sometimes amputation is necessary and indicated as a last resort to achieve this end.

Arterial Aneurysm

Any condition which weakens the wall of a vessel or increases the intra-arterial pressure is a cause for arterial aneurysm. A blood containing cavity which communicates with the artery is the result. This sac normally has a neck where it communicates with the main vessel and the contents of the cavity are either liquid blood or coagulated blood which is in various stages of resolution.



a b c

Fig. 12. a, Obliteration of sac by rows of suture. b, Muscle implant. In this instance a section of gastrocnemius. c, Obliteration of sac without its removal, thus protecting collateral vessels.

Symptoms. Tumor is considered synonymous with aneurysm, and it will always be found unless it is concealed beneath contiguous structures such as heavy muscles. It has an expansile pulsation until the laminations become so great as to obliterate it. The larger and later ones are not necessarily expansile. Pain is more or less a constant symptom but is most often due to pressure on other sensitive structures. Pressure signs depend entirely on the site and in the extremities are not a great factor. The pulse is always weaker or absent distal to the sac and oscillometric recording of this fact may be an early, suggestive sign. The bruit described by Paré in 1582 is present in the early aneurysm before clotting is a factor, and it is a rough, systolic type of bruit.

Pathology. The pathological picture depends on the type. The diseased arterial wall may balloon out as a sacular or fusiform dilatation. Fibroconnective tissue strives to strengthen this wall, but the pressure eventually causes further dilatation. The walls of the vessel may be pushed ahead of it, forming the so called true aneurysm, or the walls may be destroyed and the sac consist of surrounding tissues with only an endothelial lining. Clots which occur are white at the periphery and, as the lumen is approached, become red and more fluid. Many degenerative changes occur in the clots, and in the long standing ones calcified particles or calcification of the entire clot is seen (Fig. 6).

Treatment. In a small percentage of the acquired type of aneurysm an end-to-end arterial suture is possible. The artery is exposed, the aneurysm excised, and the arterial ends sutured with interrupted and continuous fine silk (Fig. 7). The suture line is then re-enforced with a section of contiguous muscular fascia (Fig. 8). This treatment is applicable only when there is no disease of the artery and when the size of the aneurysm permits approximation of the ends. Inasmuch as many of these injuries occur at or near joints, by proper flexion of the part and release of the vessel from the surrounding tissues as much as a 4 centimeter defect may be closed. Such a procedure was satisfactorily performed four times last summer on large traumatic aneurysms (Figs. 9 and 10). It is particularly important to remember this point in war surgery when many limbs are unnecessarily sacrificed.

Modifications of the reconstructive aneurysmorrhaphy. In this operation modifications of the original Matas procedure are performed. Opening of the aneurysm and plastic repair of the wall over a tube or other foreign material have been successfully accomplished in selected cases although an arterial wall once seriously damaged may weaken again. The use of an absorbable material, such as a glucose preparation, to suture over has been advocated but has many technical difficulties. Vein transplants for arterial loss have been satisfactorily introduced. These vein transplants in the absence of thrombosis work well, the vein wall constricting to the size of the arterial flow and in time hypertrophying. Heparin is indicated, especially in these patients.

Modification of Matas' obliterative aneurysmorrhaphy. This operation follows the conceptions of Philigrius of over a thousand years ago and is the operation of choice in many cases. With the circulation controlled, the sac is opened, its contents removed, and the opening of the small collaterals into the sac closed by sutures. The sac is then obliterated by layer after layer of sutures without excising the sac. Most surgeons misconstrue this conception of the technique and remove the sac with irreparable destruction of the collaterals, and the frequent result is gangrene (Fig. 11). When the sac is large, a muscle implant is most effective in obliteration.

It is interesting to consider the possibilities of other foreign matter causing periarteritis and endoarteritis in the future treatment of aneurysms and experiments at the present time are under way with such materials as talcum powder and cellophane. These and other similar substances have shown remarkable tendency to cause inflammation and fibrosis, and it may be possible to take advantage of this fact therapeutically. One such patient has already been operated upon—with cellophane wrapping of aneurysm of innominate artery.

One must remember that in any type of treatment of aneurysm in which the main vessel is or may be occluded stimulation to collateral circulation should be continued. This stimulation should be in the form of controlled, external heat, avoidance of all trauma, the antispasmotic drugs, and whiskey. The lumbar sympathetic nerve block by use of 2 per cent novocain introduced into the sympathetic ganglia has its place in relaxing spasm and opening collateral circulation. Heparinization after operations on the arteries has revolutionized this form of surgery and has made possible procedures which previously were technically impossible. Heparin is given in a continuous drip with careful and constant checking of the clotting time to keep the figure above 15 minutes. This requires diligence. Murray has stressed this point and its importance has been proved in our own clinic to our entire satisfaction. The patient should not be left alone after such an operation until the success or failure of the procedure has been determined.

No strain should be put on the part until proof of adequate circulation is present, and in those cases in which small collaterals are carrying on the circulation the patient thereafter must be restricted physically to the limits of his arterial supply.

THE OMENTUM AS A SOURCE OF NUTRITION TO EXPERIMENTALLY PRODUCED MYOCARDIAL ISCHEMIA

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ENCOURAGED by the results of our first experiments, a second series of operations, omentum to heart graft, followed by coronary artery division and ligation, was undertaken. The results show that the new vessels formed are of sufficient caliber actually to carry enough blood to nourish that part of the myocardium to which they have proliferated. As evidence of this, injected particle of red cinnabar passed readily through the arterial anastomoses that developed between the omental and coronary arteries. Cinnabar particles are larger than red blood cells and they are also unlike corpuscles in so far as they cannot be squeezed into ameboid shapes.

Electrocardiographic studies made throughout the experiments reveal serious myocardial changes following coronary artery division and ligation. The animals survive this shock with surprising ease and soon appear well except for the discomfort of the incision. Electrocardiograms show that infarcts develop, but healing progresses rapidly. It was our hope that, by first developing a sufficiently proliferative graft and then reducing the myocardial circulation, the process of infarction could be prevented.

To date we have been unsuccessful in this endeavor. All animals which had a graft and one coronary artery divided near its base recovered. On several occasions after a reasonable length of time had elapsed we divided the second coronary artery. None of these animals survived the operation by more than 10 to 30 minutes.

August 10, 1940, under intratracheal ether anesthesia with controlled artificial respiration, the left anterior chest cavity was opened and the omentum brought up through an incision in the left cupola of the diaphragm. The pericardial sac was then incised and the parietal pericardium as well as the epicardium thoroughly roughened with a burr. The omentum was then stitched with No. 00 plain catgut to the anterior and lateral walls of the heart and to the inside of the posterior portion of the pericardial sac. Special effort was made to bring the omentum well over the base and apex of the heart. The pericardial sac was left open and after the diaphragm incision was sutured so as not to strangulate the omentum, the chest wall was closed while the lungs were being artificially inflated.

On September 14, 1940, the right coronary artery was divided about 1 centimeter from its origin. The cut ends were ligated with No. 1 plain catgut. The omental graft had taken, but there were some free myocardial surfaces seen. The dog recovered rapidly, and, on October 26, 1940, a third operation was performed. On this occasion all accessible myocardium, which did not have omentum adherent to it, was roughened and omentum stitched in place. Again recovery was uneventful.

On February 13, 1941, the animal was sacrificed and a postmortem examination performed. The omentum was found to be adherent *en masse* to the myocardium, pericardium, and lungs. The coronary vessels could not be seen until they were exposed at some places by blunt dissection of the omentum and at places by dissection of the pericardium. The heart, lungs, and diaphragm were removed as one unit and the specimen was injected with red cinnabar in water, the injection being carried out through the ascending thoracic aorta. Pulsatile pressure producing an artificial systolic pressure of not more than 125 millimeters and a diastolic pressure not more than 25 millimeters no less than 0 millimeter was used. The cinnabar passed readily into the left coronary artery and then into the remnant (reticulum) of the right coronary artery. This latter vessel extended about 1 centimeter from the aorta, gave off eight very small branches and one fairly large anterior branch. The second centimeter of the right coronary artery was entirely absent, but from then on the distal portion filled completely. Before the coronary arteries had become well filled, the injected medium was seen flowing freely in numerous omental vessels and to a lesser extent in the diaphragm and lungs. The aortic valve held so perfectly that the left ventricle did not become filled with cinnabar during the injection.

This specimen was then dehydrated with alcohol and cleared by using the Spalteholz method of displacing the alcohol with benzine and then displacing the benzine with methyl salicylate. After

From the Marquette University School of Medicine, Department of Physiology.

[1]Surg. Gyn. Obst., 1941, 72:1003–1007.

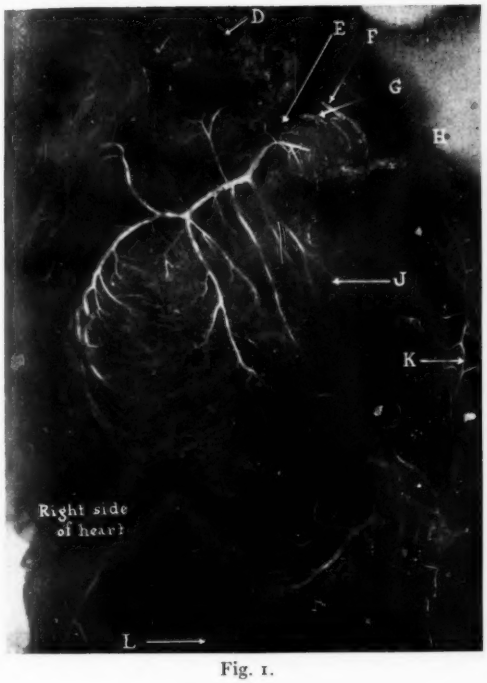


Fig. 1.

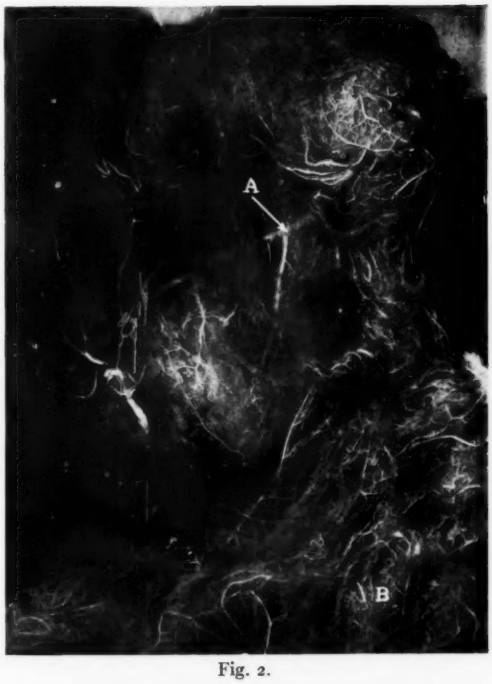


Fig. 2.

Fig. 1. *D*, right auricle; *E*, destroyed portion of right coronary artery; *F*, peripheral stump of an omental artery; *G*, branch of proximal stump of right coronary artery; *H*, adherent lung; *J*, infarct; *K*, omentum artery; *L*, diaphragm.

Fig. 2. *A*, descending ramus of left coronary artery enmeshed in vast network of anastomotic omental vessels; *B*, omentum.

Fig. 3. *C*, omental graft partially dissected away to show the origin and branches of the left coronary artery.

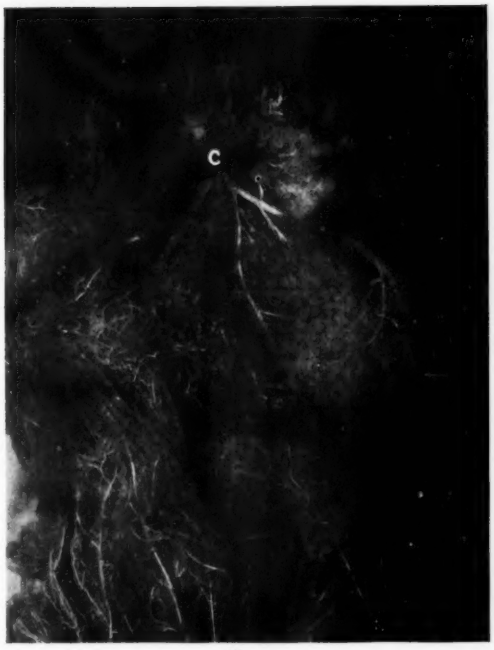
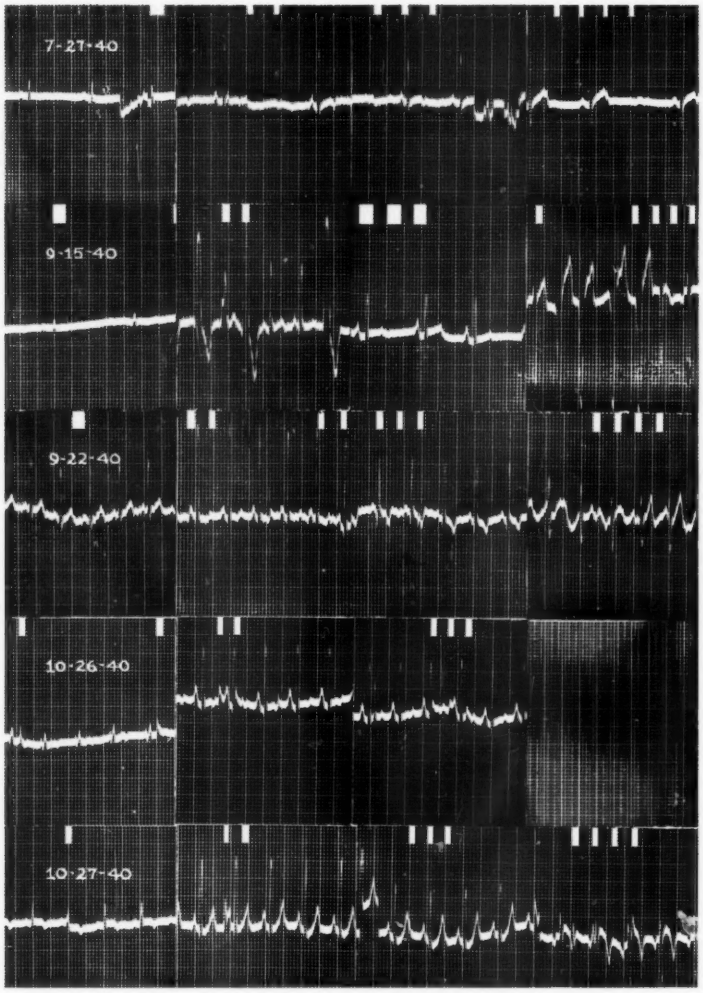


Fig. 3.



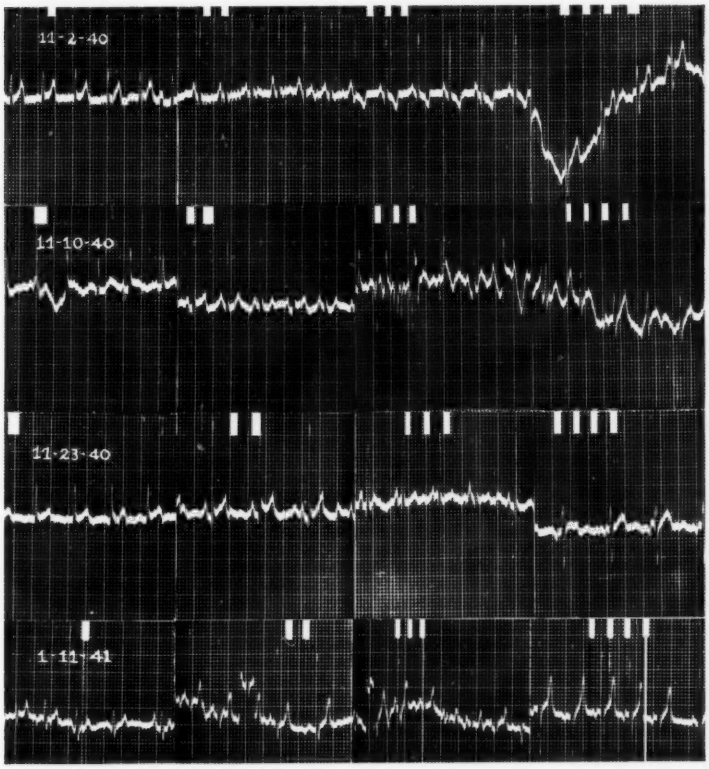
July 27, 1940. Marked sinus arrhythmia; rate, 60–150; *QRS* complexes, clean and of good amplitude in all leads; S-T_2 and S-T_3 practically isoelectric, but definitely convex upward; S-T_4, slightly elevated and slopes upward; T_2 flat; T_2 upright; *P-R*, 0.09; *QRS*, 0.04.

September 15, 1940. One day postoperative. Rhythm is composed chiefly of a succession of ventricular extopic beats with occasional runs of two to four normal beats. Rate, 190; marked right axis deviation; *QRS* complexes, notched in all leads; T_1 inverted; T_2 and T_3, upright following the normal beats; R_4 absent; T_4 ,inverted following normal beats; *P-R*, 0.08; *QRS*, 0.06. Consistent with recent myocardial infarction. Pattern suggests another apical involvement.

September 22, 1940, one week postoperative: Occasional ventricular premature contractions; sinus tachycardia; rate, 160. T_1 which was originally flat is now sharply peaked and 3 millimeters in amplitude; S-T_2 and S-T_3, slightly depressed; T_2, diphasic; T_3, which was previously upright, is now sharply inverted, T_4, upright; *P-R*, 0.08; *QRS*, 0.05. Consistent with relatively recent myocardial infarction probably involving posterior wall of left ventricle.

October 26, 1940. Sinus tachycardia, rate 170. T_2 remains upright, but is now less than 1 millimeter in amplitude. T_2 and T_3, low and diphasic; S-T_2 and S-T_3 have returned to isoelectric; no lead IV. *P-R*, 0.08; *QRS*, 0.05. Consistent with healing infarct.

October 27, 1940, 1 day postoperative, second stage. Sinus tachycardia. Rate, 150; QRS_1 increased in amplitude as compared with electrocardiogram of previous day; R_4 relatively low; S-T_1 elevated and convex upward, S-T_2 and S-T_3 depressed, S-T_4 rather markedly elevated; T_1 has become inverted, T_4 has become deeply and sharply inverted; *P-R*, 0.08; *QRS*, 0.05. Fresh anterior wall infarct.



November 2, 1940, 1 week postoperative, third stage. Sinus tachycardia. Rate, 180; T_1 and T_4 have turned sharply upright and T_3 has become sharply inverted as compared with electrocardiogram of 1 week ago; *P-R*, 0.08; *QRS*, 0.05. These changes are exactly the opposite to what would have been expected after anterior wall infarction, and present pattern is more in keeping with posterior wall infarction.

November 10, 1940. Third week postoperative. Auricular flutter with 2–1 block; auricular rate, 336, ventricular rate, 168. S-T_1 has become depressed. T-waves are obscured by auricular flutter waves. R_4 and T_4 still upright and of good amplitude. Auricular flutter is most important finding. Pattern of anterior wall infarction has disappeared suggesting complete healing. *P-R*, 0.08; *QRS*, 0.05.

November 23, 1940, fifth week postoperative. Sinus tachycardia. Rate, 150. T-waves are upright in all leads and inconstantly notched in leads II and IV. *P-R*, 0.08; *QRS*, 0.05; no residuals of previous infarction.

January 11, 1941. Sinus arrhythmia; rate, 120–190; *QRS*, increased in amplitude as compared with September 8, 1940. S-T_1 has returned to iso-electric; T_1 increased in amplitude, T_2 and T_3 have turned upright and are of considerable amplitude. *P-R*, 0.09; *QRS*, 0.05. Suggests complete healing of infarct as there is no residual in electrocardiogram.

this process was completed, dissection was carried out in such a manner that many of the established anastomoses between the coronary arteries and the arteries of the omentum and lungs (bronchial) may be seen. Numerous relatively small anastomotic connections were unavoidably destroyed in an effort to make visible the more important ones.

CONCLUSIONS

1. Rich anastomoses between the omental arteries and those of the heart can be produced surgically.

2. Anastomotic vessels are of sufficiently large dimensions to permit the blood to be carried freely through them.

FACTORS INFLUENCING THE INCIDENCE OF POSTOPERATIVE THROMBOPHLEBITIS IN GYNECOLOGIC SURGERY

VIRGIL S. COUNSELLER, M.D., F.A.C.S., and D. ANGUS McKINNON, JR., M.D.,
Rochester, Minnesota

THIS paper is based primarily on an analysis of the records of 99 patients suffering from postoperative thrombophlebitis which were selected during a review of 2,684 cases in which abdominal hysterectomy was performed consecutively for benign conditions from 1935 through 1939. A supplemental analysis will be made of 276 cases in which abdominal hysterectomy was performed consecutively in the hospital service of one of us (Counseller) for a period of about 4 months. In this supplemental analysis (276 cases) the prevention of thrombophlebitis will be considered, whereas, the former and larger group (2,684 cases) will be arranged into groups of patients with similar complicating factors, and deductions will be made on the basis of the occurrence of thrombophlebitis in these various groups.

INCIDENCE

We were primarily interested in determining the frequency of thrombophlebitis as it occurs after total or subtotal hysterectomy. Total abdominal hysterectomy was performed 1,920 times among the 2,684 patients; the 764 remaining patients underwent subtotal abdominal hysterectomy. It is evident that the frequency of postoperative thrombophlebitis is higher among those patients who underwent subtotal hysterectomy than among those who underwent total hysterectomy since in the 1,920 patients upon whom total hysterectomy was performed postoperative thrombophlebitis occurred in 66 patients, or 3.4 per cent, and in the 764 patients upon whom subtotal abdominal hysterectomy was done postoperative thrombophlebitis occurred in 33 patients, or 4.3 per cent, an incidence of 3.7 per cent for the entire 2,684 cases. To eliminate as many other variables as possible and still further test this trend, we chose records of "excellent risk" patients from among records of the 2,684 patients. These patients were considered to constitute excellent risks because they presented no demonstrable disabilities such as hypertension, severe anemia, marked obesity or diabetes. By elimination of all cases in which undesirable factors were present, we finally obtained records of 1,034 patients who underwent total abdominal hysterectomy and 463 patients who underwent subtotal abdominal hysterectomy. In the first group postoperative thrombophlebitis occurred in 23 patients, or 2.1 per cent; in the second in 14 patients, or 3.0 per cent—an incidence of 2.5 per cent for the entire group of 1,497 cases. Thus it is shown that the same difference of occurrence of thrombophlebitis depicted in the total group of patients still exists. On the basis of these two figures a justifiable conclusion may be drawn: total abdominal hysterectomy is followed by a lower incidence of postoperative thrombophlebitis than is subtotal abdominal hysterectomy. The explanation of this difference probably lies in the relationship of the operation to the broad ligament. In subtotal hysterectomy the veins in the broad ligament are traumatized and left in place, whereas in total hysterectomy most of the veins are excised or shortened and less endothelial surface consequently is left to act as a focus for the development of thromboses. Thrombosis in these venous stumps may slow the circulation in the proximal larger vessels (internal iliac), and these in turn cause additional venous stagnation, so that there is a tendency toward the production of more thromboses. Since lack of muscular action during the first 72 hours after operation is a prime factor in the production of thrombophlebitis after any operation, and since traumatic changes in the iliac vessels subsequent to abdominal hysterectomy contribute to the process, the stage is set, so to speak, for formation of thrombophlebitis after any type of hysterectomy but even more so after the subtotal operation.

From the Division of Surgery, Mayo Clinic and Mayo Foundation.

Read before the meeting of the Western Surgical Association, St. Paul, Minnesota, December 5 and 6, 1941.

Dr. Joseph Berkson of the Division of Biometry and Medical Statistics of the Mayo Clinic and his co-workers were of great assistance in the preparation of this paper.

TABLE I.—INCIDENCE OF POSTOPERATIVE THROMBOPHLEBITIS AMONG PATIENTS WITH OPERATIVE HAZARDS AND AMONG "EXCELLENT RISK" PATIENTS

Hazard, type	Patients	Postoperative thrombophlebitis Patients	Per cent
Varicose veins	86	20	23.3
Anemia			
Hemoglobin 50 per cent or less	50	4	8.0
Hemoglobin 70 per cent or less	157	11	7.0
Obesity	145	9	6.2
Endometriosis	238	14	5.9
Infection at time of operation	258	12	4.7
None ("excellent risks")	1497	37	2.5

CAUSATION

Three possible conditions may influence the formation of thrombophlebitis: (1) slowing of the circulation, (2) changes in the venous lining membrane, and (3) changes in the circulating blood. To apply these facts to the clinical field we further divided our patients into three groups.

In group 1 were those who had varicose veins at the time of surgical intervention. There were 86 patients in this group, but also included in the group were 145 obese patients. A patient 5 feet 2 inches (157 cm.) tall weighing between 140 and 150 pounds (63.5 and 68 kg.) was considered to have obesity of grade 1. Progressive disproportion between height and weight was graded as obesity of 1, 2, 3, and 3+. One hundred and thirty-one of the aforementioned 145 patients had obesity of grade 2 or more.

In group 2 were those who had endometriosis which of necessity required the infliction of more trauma than usual in the pelvis during operation to free up the pelvic organs and to remove the implants. There were 238 patients in this group.

In group 3 were those who had a value for hemoglobin of 70 per cent or less; there were 157 such patients. Fifty of these 157 anemic patients had a value for hemoglobin of 50 per cent or less.

In contrast to data obtained in these three groups are the data concerning the 1,497 "excellent risk" patients, with the incidence of thrombophlebitis, in Table I. In this table the tremendous increase in the incidence of thrombophlebitis among patients who had varicose veins is dramatically evident. Since varicose veins will not only keep the patients in bed days or weeks longer than usual, but will also expose them to the possibility of pulmonary embolism, it is obviously a serious factor to consider before operation. If surgical intervention is not urgently and immediately necessary, we strongly advise preoperative care of varicose veins. Such veins should be treated by ligation or injection, or both, depending on the individual case.

In Table I also is shown the marked influence anemia has on the postoperative development of thrombophlebitis. As a whole, patients who have anemia are difficult to manage. Most extremely anemic patients bleed excessively and consequently their values for hemoglobin cannot be increased before operation to more nearly normal. The question of the effect of the transfusion of blood itself on the production of thrombophlebitis among anemic patients cannot be answered definitely at this time. Seventeen of the 157 anemic patients received transfused blood before operation or after operation from one to three times. Thrombophlebitis developed in only 1. Although it cannot be so stated with certainty on the basis of these figures, it seems reasonable to assume that it is far safer to transfuse blood to an anemic patient, if the indication arises, than it is to withhold blood because of the fear of producing thrombophlebitis. It might even be justifiable in these cases to resort to the preoperative prophylactic transfusion of blood.

In Table I the incidence of postoperative thrombophlebitis is shown to be about the same among obese patients (6.2 per cent) and among those who have endometriosis (5.9 per cent). The mechanism of the production of thrombophlebitis in these two groups of patients, however, probably is different. In the obese patient, slowing of the circulation because of lack of muscular action tends toward stagnation and formation of thrombi, whereas in the patient who has endometriosis, trauma to the iliac veins necessarily incident to the removal of pelvic implants is a more likely precipitating factor. Since the incidence of thrombophlebitis is roughly two to three times more frequent in these two conditions (6.2 per cent and 5.9 per cent, respectively) than in patients considered to be "excellent risks" (2.5 per cent) it would seem to be wise to seek active measures for the prevention of phlebitis among obese and anemic patients. In Table I it is also shown that the incidence of thrombophlebitis is almost doubled (4.7 per cent) when infection is found at the time of operation, as compared to the incidence of thrombophlebitis (2.5 per cent) when patients are considered to be "excellent risks."

SITUATION

Thrombophlebitis occurred in the lower extremities in 75 per cent of the 99 cases. In practically all of the 25 per cent remaining thrombophlebitis probably also occurred in the leg, although this was not stated specifically in the records. Our

entire data are based on the clinical diagnosis of thrombophlebitis. No extra information obtained at necropsy has been included, other than confirmation of the cause of death.

In 30 per cent of the 99 cases, thrombophlebitis occurred in superficial varices or occurred in the form of mild attacks in the small or great saphenous vein. Elevation of the leg and hot applications were used for a few days, but none of these patients required postoperative support of the extremities for the prevention of swelling. Incidentally, pulmonary embolism occurred only once in this group.

In 43 per cent of the 99 cases there was involvement of the femoral vein which may or may not have been associated with involvement of the iliac veins, or which may have constituted a severe attack involving the great saphenous vein. All patients in this group required elevation of the affected part and the application of large, hot, wet dressings during the acute phase, and some form of support for a variable length of time after dismissal. The situation and extent of involvement in the remaining cases were not stated.

ONSET

The onset of thrombophlebitis varied from the 2d to the 28th postoperative day. In 75 per cent of cases the condition began between the 8th and 16th day after operation. More specifically, in 55 per cent of cases thrombophlebitis occurred between the 9th and 14th days. In only 3 per cent of cases did thrombophlebitis occur before the 7th postoperative day. It is a known fact that thrombophlebitis may be fairly extensive without its being possible to diagnose it clinically. Consequently, we have stated the day on which the condition was diagnosed, which may or may not be the day on which the condition began. Actually, we believe that thrombosis occurs, or at least begins, within the first 3 days after operation, and becomes evident only when muscular action causes symptoms to arise because of venous obstruction. Extension of the thrombosis also may be a factor in the clinical diagnosis.

PREVENTIVE TREATMENT

Proceeding on the assumption that by increasing the rate of venous return from the extremities we would be able to eliminate one of the essential factors in the production of postoperative thrombophlebitis, the following procedure was instituted for 276 patients recovering from gynecologic operations on the service of one of us (Counseller) for a period of, roughly, 4 months. No patients were included who required less than 7 days of rest in bed after operation. Alternate patients from each day's list were used as controls. Because an odd number of patients underwent operation on different days, the number (146) of patients in the control group slightly exceeds the number (130) of patients on which the preventive therapeusis was based. In short, each alternate patient was placed in bed after operation and the legs were elevated immediately on pillows, so that the heels and forelegs were roughly 8 inches (20 cm.) higher than the buttocks. A cradle containing two light bulbs (20 watts each) was placed over the legs so as to include the feet and part of the thighs. A cover (blanket, bedspread, or sheet) was then placed over the cradle. An ordinary thermometer was placed under the cradle and the temperature was maintained at 85 degrees F. (29.4° c.). This part of the procedure was the most difficult to carry out. It requires frequent inspection of the thermometer and the turning on and off of the light bulbs, as indicated. A thermostat will greatly simplify this problem. Most of the patients found the position and temperature at least tolerable, a few disliked it intensely, and a few felt more comfortable under the cradle. An occasional patient was not included because of poor co-operation. In the control series of 146 patients the incidence of thrombophlebitis was higher (6 patients, or 4.1 per cent) than it was in the series of 130 treated patients (3 patients, or 2.3 per cent). Too much importance should not be attached to this observation, however, because closer analysis reveals that one less instance of thrombophlebitis in the control group and one more instance of it in the treated group would make the percentile incidence of thrombophlebitis practically the same for both groups. These figures are not "statistically significant." Nevertheless, this preliminary report indicates that a slight advantage was obtained by our efforts. It will require a considerably larger group of patients to prove our assumption definitely.

SUMMARY

An analysis of thrombophlebitis, occurring after abdominal hysterectomy had been performed 2,684 times for benign conditions, has been presented. The occurrence of thrombophlebitis in another, and separate, group of 276 patients has been discussed. Patients among whom thrombophlebitis developed have been grouped according to the type of physical hazard they presented at operation, and according to the type of operation performed. On the basis of the incidence of thrombophlebitis in these different groups, certain deductions have been drawn. A possible

method of lowering the incidence of thrombophlebitis has been presented.

CONCLUSIONS

The incidence of postoperative thrombophlebitis is higher after subtotal abdominal hysterectomy has been performed than it is after total abdominal hysterectomy.

The presence of varicose veins is the greatest single predisposing factor in the production of postoperative thrombophlebitis, the incidence of thrombophlebitis being roughly ten times higher among patients who have varicose veins than it is among patients who are considered to be "excellent risks."

Severe anemia increases the incidence about three times, and obesity, infection, and endometriosis increase the incidence approximately two times.

The preoperative and postoperative transfusion of blood probably does not markedly increase the incidence of thrombophlebitis.

Elevation of the legs and the application of constant dry heat after operation probably lower the incidence of thrombophlebitis in the lower extremities.

EDITORIALS

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JULY, 1942

MILITARY MEDICAL INTELLIGENCE FROM RUSSIA

THE medical problems of modern warfare are obviously different from those encountered in the last great war in view of the predominant rôle of mechanized equipment and the ever increasing importance of the air arm in conjunction with the forces on land or sea. The campaigns of the last year on the Russian Front exemplify the most extensive fighting by modern arms that has yet taken place. The editors of SURGERY, GYNECOLOGY AND OBSTETRICS have endeavored to obtain information from Russian sources concerning the medical problems with which the Russian Army has been faced in the last year. Information has indeed been fragmentary. However, there follows a summary of several reports obtained from the Russian Embassy in Washington, D. C.:

"In spite of all difficulties and complexities of modern warfare, it has been found possible to bring qualified medical aid within the maximum proximity to the front lines.

"Operations on intestinal and pulmonary organs are performed under the worst primitive conditions—in dugouts, tents, and huts. But even under these primitive conditions no departure from the fundamental requirements of antiseptic surgery is tolerated. Surgeons invariably operate in sterilized smocks, in gloves and masks, with portable electric lamps and good instruments.

"Dressings are sterilized on the spot by each medical battalion or traveling field dressing station. Autoclaves are set up usually in a dugout or small tent and maintain a steady supply of sterilized material day and night.

"Many lives have been saved, thanks to a splendidly organized blood transfusion service. Blood donated by all sections of the population and collected at stations set up in all rural and metropolitan communities is conserved in isothermal containers and sent by airplane and motor truck not only to the larger hospitals but to dressing stations located at the most advanced lines of the front. Shortage of blood for transfusion purposes has never been a problem since, if conserved blood is not at hand, donors are readily found among the medical personnel.

"There has been a sharp decline in incidence and mortality from anaerobic infections, attributed to early proper surgical treatment of infected wounds and the injection of prophylactic and curative serums. Tetanus is infrequent, this being in sharp contrast to the last World War.

"Since the Soviet counter offensive was launched amid severe winter conditions, considerable attention was paid to the prevention of frostbite among the evacuated. Such measures included heated ambulance cars, fur and

padded blanket bags improvised with padded dressings, extensive use of chemical heating pads, and frequent warming and feeding stations along the ambulance car routes. 'Men frostbitten during battle were immediately dispatched to field or rear hospitals for treatment. This was usually conducted by the 'open method with the help of physiotherapeutical apparatus.'

"The Red Army has widely developed a system of specialized medical aid. Wounds of the skull, eye, face, jaw, chest, and limbs—especially fractures of the thigh—are each treated in a special hospital. Even such apparently simple injuries as finger and wrist wounds are treated in special hospitals where the prime care is to restore the normal functioning of the damaged parts.

"In the hospitals for the treatment of light wounds in each army area—sometimes housed in dugouts, tents, cottages or huts—systematic treatment is given, including curative physical culture, the latter consisting of local and general gymnastic exercises, sports, and games. 'Labor therapy' for which special workshops are set aside, training, walking games, in the open air, and lastly military exercises, are all designed to render the lightly wounded fit for return to the ranks.

"In addition, hospitals for the lightly wounded are equipped with quartz lamps, paraffin baths, and other methods of heat treatment for facilitating absorption of infiltrations and swellings, and to speed regeneration of injured tissue. Special care is exercised to prevent chronic contractions, immobility of joints and other deformations that might make permanent invalids of the wounded.

"The 'functional cure' of limbs injured by firearms is widely practiced, employing, when necessary, plaster-of-paris dressings at proper intervals, and a regimen of alternating movement and rest.

"Regular conferences in base hospitals and at the front are held at which papers are read by eminent surgeons. In addition, younger surgeons present their own communications and demonstrations based upon their actual experiences in the field. The latter are summarized and analyzed and form an important basis for the development of the newer field surgery."

ALEXANDER BRUNSCHWIG.

THE SURGEON AT HOME MUST CONSERVE HIS STRENGTH

"So Much To Do, So Little Time In Which To Do It"

THESE words are attributed to Cecil Rhodes in the year of his death. They might be spoken today by every American surgeon. It is not my purpose to list the innumerable demands that are made upon our days and nights, for we are all fully aware of them. It is, however, my purpose to direct the reader's thought to the necessity of saving time, and to suggest ways and means whereby this can be done. The ordeal which lies ahead of us makes it imperative that we find ways to increase our efficiency. Surgeons who are in the military service will find that their schedule of activities is arranged for them. This editorial is not directed to them but to the members of the profession who have the task of carrying on at home. The demands that are going to be made upon our time will become increasingly heavy not only for the duration of the war but for some years thereafter. In speaking of the duration of the war let us for once be realists and admit the likelihood of its lasting at least five years more and probably seven. During this time the number of well trained surgical residents will not begin to fill the vacancies caused by death and incapacitating illness. It

behooves us, therefore, to look carefully into our use of time, which is just another way of saying that we must give thought as to how we may conserve our individual strength.

The first suggestion that is offered is for us to recognize the unproductive activities that waste time. Are we making the maximum use of time-saving devices,—the typewriter, the dictaphone, the portable telephone, the airplane? How much do we now do that might be done equally well by a secretary or a technician?

Second, let us ask ourselves what are the circumstances that determine our activities? Is our day's work governed primarily by the sequence or the urgency of the demands made upon us, or are we able to plan a schedule in advance? If the former is true, then it follows that we are constantly working under pressure in a haphazard, harassing manner. To continue to do so during the next few years would be inexcusably stupid. On the other hand, if we are in the habit of planning our day's work, what are the usual sources of interference that wreck our plans? What can be done to protect ourselves from interruption? The answers to these questions must be worked out individually, but one suggestion may be of help. In India the polite guest always waits for his host to rise first and thus indicate that the time has come for the guest to leave. This attitude is highly intelligent, for how can a guest tell what his host wants to do? Might we not imitate this oriental custom and make it a habit to rise and plead an urgent call whenever our time is being wasted by an unimportant visitor? Of course, we might have an agreement with the secretary to provide an appropriate interruption.

On a recent visit to the office of a certain Captain in the Medical Department of the Navy I was confronted by a large poster over the desk which read as follows:

TIME ALLOWED IN THIS OFFICE FOR VISITORS

	Min.	Sec.
Friends	2	
Friends with a scheme		30
Insurance brokers		0
Contact men		30
Salesmen		5
All others		3

Third, all of us are guilty of a certain amount of lost motion. Part of every day is wasted because we sometimes move slowly or awkwardly. The commonest cause for this is fatigue. Would it not be intelligent for us to follow the advice we give our patients when we tell them not to get tired out? Most of us become fatigued because we take on more than we can do easily. This is no time for doctors to make fools of themselves in their effort to serve their communities or the public at large. It is a time for them to say *NO* emphatically to every nonprofessional request that takes time or effort. We must conserve our strength for our work. Furthermore, it is not enough to refrain from certain nonprofessional activities; many of the surgeons in America might wisely limit the range of their professional work as well. The pediatricians in a city in an eastern state are considering dividing the city into districts and confining their cases to their respective zones. Might not the efficiency of surgeons in many communities be enhanced if agreements could be reached whereby their operative cases were segregated in one or two hospitals? In England and on the Continent it has been necessary to assign doctors to certain districts and to force them to restrict their activities to the assigned area. The shortage of doctors for the civilian population in the United States may become so great that similar measures will have to be instituted; but before such measures become mandatory it would be an intelligent move for many of us to set up self-imposed restrictions. The present emergency

affords us an excellent opportunity to make the public realize that they must be as considerate in the demands they make on our time as they are in the demands they make on their attorney's time. People need to be taught that during the war doctors have no time to waste and that it is to their advantage to keep their own doctor from being exhausted through overwork.

Finally, it is imperative that surgeons give serious thought to the matter of their leisure time; first, to see to it that they have at least one period a week when they are inaccessible, and second, to use that period wisely. How this is accomplished is a matter for each individual to settle for himself.

To sum up, the time has come when it is necessary to face the fact that all of us are going to have to do much more work than heretofore. To do this without physical and mental impairment it is necessary for us to scrutinize our use of time and to have the fortitude to make the necessary alterations in our activities. To fail to do so will certainly be foolish. It may be fatal.

WARFIELD M. FIROR.

MEMOIRS

JOHN M. T. FINNEY

1863-1942

JOHN MILLER TURPIN FINNEY, who died at his home in Baltimore on May 30, 1942, was born on a plantation near Natchez, Mississippi, on June 30, 1863. He was the son of Ebenezer Dickey Finney, a Presbyterian minister, and Anne Louise (Parker) Finney. After his mother's death, five months after his birth, he was taken into the family of Mrs. Stephen Turpin, a warm personal friend of his father and mother, a granddaughter of Dr. John Archer, the first graduate in medicine in this country. The Turpin in his name was inserted by his father in recognition of Mrs. Turpin's great kindness to him. Incidentally, Mrs. Turpin was the first of his four foster mothers.

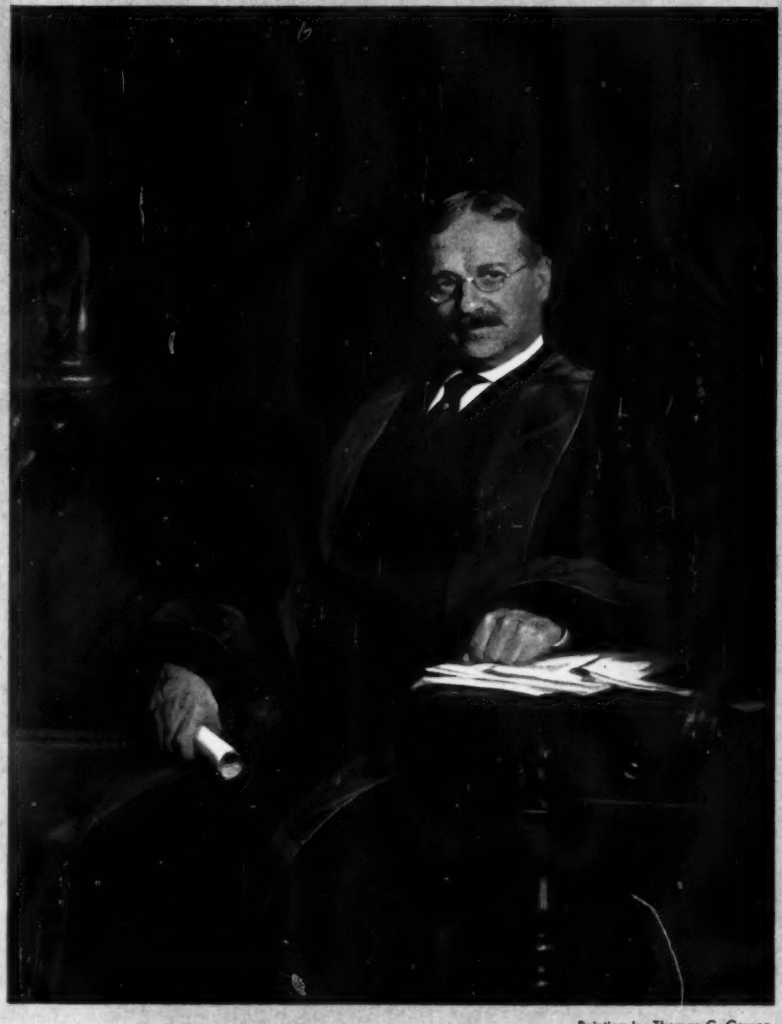
Dr. Finney was graduated from the College of New Jersey, now Princeton University, with the degree of A.B. in 1884, on his twenty-first birthday. He entered the Harvard Medical School and graduated in 1889, an extra year being necessitated by a severe attack of typhoid fever during his third year.

Following his graduation in Medicine he received an appointment on the resident surgical staff of the Massachusetts General Hospital where he came in intimate contact with Dr. C. B. Porter, Dr. John Homans, Dr. Arthur T. Cabot, and his life long friend and associate, Dr. William S. Thayer.

On May 7, 1889, the Johns Hopkins Hospital was opened and on that day Dr. Finney received from Dr. Halsted an appointment on the Surgical Staff in charge of the dispensary. That was the beginning of his long association with Johns Hopkins where he passed through various appointments until Dr. Halsted's death in 1923, when he was appointed acting professor of surgery and surgeon-in-chief to the hospital, which positions he held until he was succeeded by Dr. Dean D. Lewis, in 1925. On reaching the age of seventy in 1933 he was made emeritus professor of surgery.

In 1917, Dr. Finney went to France with Base Hospital No. 18 as its director, with the rank of Major in the Medical Corps. It was not long before he was appointed chief consultant in surgery of the A. E. F. with the rank of Colonel and later that of Brigadier General. His headquarters were at Neufchateau where he had under him the Chiefs of the Surgical Specialties. For his work in France he was awarded the Distinguished Service Medal, was made Commandeur de l'Ordre de la Courounne (Belgium), and Officer de la Legion d'Honneur (France).

He received many honors as a reward for his distinguished position in the



Painting by Thomas C. Corner

JOHN M. T. FINNEY

JUNE 20, 1863—MAY 30, 1942

surgical world. In 1927 he delivered the Hunterian Lecture before the Hunterian Society of London and was made an Honorary Member of the Society. In 1932 he gave an address before the Boston Surgical Society and received the Bigelow Medal for "Achievement in Surgery." He was an honorary member of the Medical Society of London, the Royal College of Surgeons of England, the Royal College of Surgeons of Ireland, and the Royal College of Surgeons of Edinburgh. Honorary L.L.D's. were conferred upon him by Tulane University in 1935, by Harvard in 1937, and by Loyola College, of Baltimore, in 1940.

He was one of the founders and the first president of the American College of Surgeons (President, 1913–1916; member of Board of Regents, 1913–1934; member of the Advisory Council of the Board of Regents 1937-1942), a member of the American Surgical Association (president, 1921), the Southern Surgical Association (president, 1912), the Medical and Chirurgical Faculty of Maryland (president, 1934–35), the Society of Clinical Surgery, and other medical societies. From 1913 until his death Dr. Finney was a member of the editorial board of SURGERY, GYNECOLOGY AND OBSTETRICS.

For many years he had been keenly interested in education. He was a trustee of Princeton University for some years and, when Woodrow Wilson became governor of New Jersey, he was offered the presidency of the University. After much thought and consultation and on the earnest solicitation of the citizens of Baltimore, he decided to decline the invitation. On his decision to remain in Baltimore, a large testimonial dinner was given in his honor at which a fund, which had been raised by his friends, was presented to the State Medical Society to be known as the "John M. T. Finney Fund for the Advancement of Surgery," the income to be used for lectures and the purchase of books and journals relating to surgery. His interest in general education was manifested by the Boards on which he served. In addition to being a life trustee of Princeton University, he was also a trustee of Lincoln University and the Princeton Theological Seminary. At one time he was a member of the school board of Baltimore and until his death was a member of the State Board of Education and the president of the Boards of the Gilman School for Boys and McDonogh School.

When he began to practice in Baltimore he was handicapped by the fact that he was given no privileges either in the public or private wards at the Johns Hopkins Hospital. This made it necessary for him to seek other facilities where he could operate on his private patients. He began to use the Union Protestant Infirmary and, as his practice grew, he became the outstanding member of the staff. Finally, in 1919, he acted as the chairman of a campaign committee to raise funds for a new hospital, and it was largely through his efforts that the present Union Memorial Hospital developed as the successor of the old Infirmary. He had had in mind for a long time that there should be some provision made for the hospital care of patients of moderate means, and whenever the opportunity

offered, he would talk it over with his patients and friends. Finally, one of his admiring patients, Mr. Frederick Bauernschmidt, sent for him and told him that he was setting aside a considerable sum of money which he proposed to devote to the construction and equipment of such a building. On Dr. Finney's advice he erected such a building in 1929 on the grounds of the Union Memorial Hospital, the first to be erected in this country for the care of people of moderate means. He confined his work largely to the Union Memorial Hospital, and it was frequently spoken of as Dr. Finney's Hospital.

Dr. Finney belonged to that group often spoken of as Master Surgeons. He was pre-eminent and was familiary called the "King" by the house officers. His surgical judgment both as an operator and as a diagnostician was one of his outstanding qualities and his advice was eagerly sought by his colleagues in obscure and difficult cases.

As an operator he was at home in any field, but he was probably best known as an abdominal surgeon, being especially interested in lesions of the stomach and duodenum. For many years he advocated the operation of pyloroplasty, which bears his name, for duodenal ulcer. He was the author of numerous papers on surgical subjects and frequently took part in the discussions at medical and surgical meetings. In 1940 he published his autobiography, *A Surgeon's Life.*

At the time of his death Dr. Finney was looked upon as the first citizen of Baltimore. He was always interested in public affairs and served on many state and city commissions. He had been the chairman of the Community Fund and for the past few years, the chairman of the Baltimore Chapter of the American Red Cross. On two occasions he was mentioned as a candidate for Governor and for United States Senator, both of which he declined.

As a man, his outstanding qualities were his integrity, his saneness, his loyalty, and a forgiving nature, which had their origin in his Christianity. These sterling qualities were illuminated by a social charm and a delightful sense of humor.

Dr. Finney had a host of devoted friends. One of the closest, Dr. George Walker, conceived the idea of presenting to Dr. Finney a parchment copy of Rudyard Kipling's poem "IF," as he felt that Dr. Finney so fittingly represented the qualities of manhood set forth in it. Dr. Walker made a special trip to London to have Mr. Kipling autograph the copy. This was done forty-eight hours before Mr. Kipling's death and was probably the last thing he signed.

This same friend, Dr. Walker, died within a few months, and left his entire estate—a considerable one—to establish the Finney-Howell Research Foundation for the Investigation of Cancer.

Dr. Finney always took a lively interest in sports of many kinds. As a student at Princeton he played on the Varsity football team and while at the Harvard Medical School he also played on the Varsity team of that institution—the only instance in which a man played on both the Princeton and the Harvard Varsity

teams. He was always an enthusiastic supporter of the athletic activities of his Alma Mater. He was fond of hunting and fishing, and in Nova Scotia, where he spent his summers, he waded many of its rivers in pursuit of salmon.

He is survived by his widow, Mary E. Gross Finney, two sons who are surgeons, John M. T. Finney, Jr., and George Gross Finney, a third son Eben Dickey Finney, an architect, and a daughter, Mrs. James S. McDonnell.

To all who knew him personally or by reputation, Dr. Finney was the ideal physician, selfless in his devotion to his profession, inspiring younger men by his ability, and by his unfailing service to all of his patients, regardless of race, creed, or station in life. In his death the medical profession has lost one of its most distinguished and beloved members, and the Country a valuable and loyal citizen.

WILLIAM A. FISHER

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE author of *The Microbe's Challenge*[1] is a man with evident knowledge and understanding of his subject and exceptional writing ability. Designed for the intelligent reader its simplicity and clarity of expression are without condescension. Unlike most books written for the laity, the substance is not neglected for the spectacular and arresting. The style is simple without sacrifice of exactness, dignified yet leavened and animated by intriguing chapter headings and pithy phrases. Microbiology is treated as a dynamic branch of science, in its relation to agriculture, industry, and particularly to disease and public health. The discoveries and advances and great gains in prevention of disease are entertainingly and accurately described; still it is made clear that the problems ahead are many. To the defenses elaborated against them the microbes present, through their adaptability, an ever changing front as a challenge to man's supremacy. This is the theme of the story. This book may be recommended unhesitatingly to the lay reader, attracted to science, as an interesting and informative one and also to the microbiologist, physician, or public health worker who will in addition find it provocative. A. A. DAY.

THE author of *The Modern Treatment of Syphilis*[2] has provided an appraisal of accomplishments in syphilotherapy since 1905 and a comprehensive presentation of modern treatment methods. The monograph is based largely on studies made in the syphilis division of Johns Hopkins Hospital and on the contributions of the Co-operative Clinic Group composed of chiefs of the Syphilis Clinics of the University of Pennsylvania, the Mayo Clinic, the University of Michigan, Western Reserve University, Johns Hopkins University, and of representatives of the United States Public Health Service.

Recent appreciation of the prevalence of syphilis and the importance of its control as a part of national defense has created a greater desire in the general practitioner, as well as in the specialist, to be familiar with the latest developments and the most approved treatment methods. That the author had the needs of the general practitioner in mind is evident by the directness of presentation. While the statistical approach is used, since Dr. Moore believes the most reliable decisions are based on the average response of a large group, the text is interesting as well as convincing.

In the second edition, 28 of the 32 original chapters have been completely rewritten. Two chapters have been added, one dealing with the public health and one with the massive arsenotherapy. Of special interest to those familiar with the first edition will be the chapters on the interpretation of serologic tests in diagnosis and treatment control, on the treatment of cardiovascular involvement, and on the prevention of prenatal syphilis. An entire chapter is devoted to the consideration of the ever recurring questions of infectiousness, prognosis, and cure.

In the chapter devoted to public health, attention is called to the fact that syphilis is the only major infection in which the spread can be controlled only by treatment of the infectious patient and by no other method. It is stated that this fact has necessitated the growth of free clinics since half of the infectious individuals cannot pay for any part of their medical care, and a large proportion of the remainder can contribute only a small fraction of its cost. It is stated that syphilis constitutes a challenge to physicians and public health officials, demanding the most intelligent thought and utmost effort.

The chapter dealing with the intensive arsenotherapy reflects a most conservative, but open minded approach to the subject. Regret is expressed that fundamental laboratory data concerning the "five-day" treatment were not accumulated before the method was tried clinically. The author states, however, that if it can be established that this method of treatment can accomplish as much in 5 to 20 days as is now accomplished in 18 months by the standard treatment and with no greater risk to the patient, it will be the greatest advance in syphilis therapy since the discovery of arsphenamine.

Each chapter is followed by a well selected bibliography on all important points with particular emphasis on recent publications. This book is highly recommended, both as a manual for the specialist and as a textbook for the practicing physician.

BERTHA SHAFER.

IN a treatise of 400 pages on the subject of toxemias of pregnancy[3] the authors have attempted to cover this subject from its earliest history, reviewing the trend in its development particularly that referring to the early treatment; this with a comprehensive review of the important research that has

[1] THE MICROBE'S CHALLENGE. By Frederick Eberson, Ph.D., M.D. Lancaster, Pennsylvania: The Jaques Cattell Press, 1941.

[2] THE MODERN TREATMENT OF SYPHILIS. By Joseph Earle Moore, M.D., with the collaboration of Gerald E. Kemp, M.D., Harry Eagle, M.D., Paul Padget, M.D., and Mary Stewart Goodwin, M.D. 2 ed., Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1941.

[3] PRE-ECLAMPTIC AND ECLAMPTIC TOXEMIA OF PREGNANCY. By Lewis Dexter, A.B., M.D., and Soma Weiss, A.B., M.D. Boston: Little Brown & Co., 1941.

been done in relation to this subject, and a report of their own studies on a series of 80 patients comprise the contents of this work.

Edema and its manifestations in normal pregnancy and in toxemia is the first subject considered. One hundred patients with generalized edema and 100 patients without generalized edema in pregnancy constitute the material from which their observations in regard to this phase of toxemia were made. Observations and other studies are described and the findings summarized. The importance of the appearance of generalized edema in pregnancy is stressed. Various possible etiological factors are discussed and the chapter on this subject closes with the statement that "by exclusion, a primary humoral etiology is suspected."

The relation of the pressor faction of the posterior pituitary to the hypertension of toxemia of pregnancy is the next subject considered in this volume. References to the experimental work of other investigators are stated and this is followed by the experimental work of the authors in which they present the data obtained by the administration of pitressin in single and multiple doses to test animals. They were unable to produce a permanent hypertension in rabbits by this substance. The toxic effects of pituitary substance is emphasized and some cases of collapse following its administration are cited. Similar studies on placental extracts with the idea of demonstrating the presence or absence of a pressor substance in the placenta resulted in negative values.

Hormonal injections into test animals failed to have any effect upon their blood pressure or urine.

One third of the volume is devoted to a discussion of pre-eclampsia and eclampsia in which the authors present the results of their observations on 80 patients who manifested symptoms of this condition. All phases of the condition are discussed and frequent references are made to the work of other investigators. This chapter closes with a hypothesis —another hypothesis, naming the placenta as the offending factor in the production of the group of symptoms called toxemia of pregnancy. However, no evidence is offered in support of such a hypothesis.

The remainder of the volume consists of the various forms of treatment that are employed in the control of toxemias. The methods employed in two of the foremost obstetrical institutions are presented in detail and other methods are discussed. From a practical point of view this book will be of little value to the general practitioner or medical student, however its value to anyone especially interested in the toxemias of pregnancy must be emphasized for it has one of the best bibliographies on this subject to be found anywhere. CHESTER C. DOHERTY.

THE new and greatly enlarged second edition of *The Autonomic Nervous System*[1] is a worthy successor to the eminently successful first edition of 1935. In fact, this monograph is so largely rewritten and so many new subjects are presented that it is more like a first edition.

Here is one ready source where the anatomy, physiology, pharmacology, and surgical treatment of the autonomic nervous system may be found in a concise, accurate, even "simplified" form. Much of the book is solidly factual, and this material is obviously not meant to be used for continuous reading, but rather for specific reference. The running text, however, makes most interesting reading, for the style is not formal or didactic. The current literature is constantly referred to. This book is highly informative and practicable in its application, and while the opinions and results of many investigators are given, they are wisely presented by the authors at their face value, for the rapidly changing status of our information concerning the autonomics during the past few years indicates the necessity for guard against overenthusiasm for "new discoveries."

This book rightly deserves wide publicity and use for several reasons. It honestly sets forth the beliefs not only of the authors, whose experience in investigative work on the autonomic nervous system is well known, but also the results of research of many other investigators of tested reliability. The present day concept of the physiology of the hypothalamus and midbrain in its practical application is presented in interesting, easily understood form. The physical arrangement of the book makes it useful not only as a reference for the investigator or surgeon, but also as a text for the advanced medical student. The simple, clear line drawings and charts are a fortunate addition to the text, and the extensive, up-to-date bibliography alone makes the book well worth owning.

JOHN MARTIN.

THE 9th edition of *Diseases of Women*[2] by Crossen devotes 100 pages to the anatomy and physiology of the pelvic organs. Physiology predominates, which is in keeping with the trend of gynecology at the present time. The discussion of the endocrines and the ovarian and endometrial relationship is timely, concise, simply worded, and readily understood. It is an excellent summary of our present day knowledge and is valuable for the practitioner as well as the student. Vaginal smear studies are thoroughly described.

Minute details of gynecological history taking and examination, which are essential for the establishment of an accurate diagnosis, are stressed.

The gynecological treatment measures are described in a separate chapter. This makes the book valuable as a readily available reference on the recent methods of management.

A considerable portion of the book is devoted to the diseases of the external genitals and vagina.

The chapter dealing with cancer of the uterus is particularly good.

[1] THE AUTONOMIC NERVOUS SYSTEM; ANATOMY, PHYSIOLOGY AND SURGICAL APPLICATION. By James C. White, M.D., and Reginald H. SMITHWICK, M.D. 2d ed. New York: The Macmillan Co., 1941.

[2] DISEASES OF WOMEN. By Harry Sturgeon Crossen, M.D., F.A.C.S., and Robert James Crossen, A.B., M.D. 9th ed. St. Louis: The C. V. Mosby Co., 1941.

Medicolegal points in gynecology are included which is a unique feature of this book.

One of the most important considerations in the book is the discussion and the many gross photographs and photomicrographs of the pathological tissues. The excellent handling of this subject makes the book rate as an excellent treatise on gynecological pathology.

The numerous figures, which number 1127, and the extensive bibliography suit this book to the needs of all who are interested in gynecology.

HAROLD O. JONES.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

UROLOGICAL DISEASES OF PREGNANCY. By E. Granville Crabtree, M.D. Boston: Little, Brown & Co., 1942.

THE BOND BETWEEN US; THE THIRD COMPONENT. By Frederic Loomis, M.D. New York: Alfred A. Knopf, 1942.

THE HISTORY AND EVOLUTION OF SURGICAL INSTRUMENTS. By Dr. C. J. S. Thompson. New York: Schuman's, 1942.

BOLETÍN DEL INSTITUTO DE CLÍNICA QUIRÚRGICA, OCTUBRE-DICIEMBRE, 1941. Buenos Aires: Universidad de Buenos Aires, 1941.

SURGICAL PHYSIOLOGY. By Joseph Nash, M.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1942.

QUISTES HIDATÍDICOS DEL BAZO. By Clemente J. L. Morel. Buenos Aires: El Ateneo, 1942.

SYNOPSIS OF ANO-RECTAL DISEASES. By Louis J. Hirschman, M.D., F.A.C.S., 2d ed. St. Louis: The C. V. Mosby Co., 1942.

CARCINOMA AND OTHER MALIGNANT LESIONS OF THE STOMACH. By Waltman Walters, B.S., M.D., M.S. (Surg.), D.Sc., F.A.C.S., Howard K. Gray, B.S., M.D., M.S. (Surg.), F.A.C.S., and James T. Priestley, B.A., M.D., M.S. (Exper. Surg.), Ph.D. (Surg.), F.A.C.S. Philadelphia and London: W. B. Saunders Co., 1942.

PATHOLOGY OF THE ORAL CAVITY. By Lester Richard Cahn, D.D.S. Baltimore: The Williams & Wilkins Co., 1941.

O PNEUMOTÓRAX EXTRA-PLEURAL. By Euryclides de Jesus Zerbini. 2d ed. São Paulo: Revista de Cirurgia de S. Paulo, 1941.

OPERACIONES URGENTES. By W. Tejerina Fotheringham. Vols. 1 and 2. Buenos Aires: El Ateneo, 1942.

THE PRINCIPLES OF ANATOMY AS SEEN IN THE HAND. By Frederic Wood Jones, D.Sc. (Lond., Adelaide and Melbourne), F.R.S., F.R.C.S. 2d ed. Baltimore: The Williams & Wilkins Co., 1942.

VASCULAR SCLEROSIS; WITH SPECIAL REFERENCE TO ARTERIOSCLEROSIS; PATHOLOGY, PATHOGENESIS, ETIOLOGY, DIAGNOSIS, PROGNOSIS, TREATMENT. By Eli Moschcowitz, A.B., M.D. London, New York, and Toronto: Oxford University Press, 1942.

DISABILITY EVALUATION; PRINCIPLES OF TREATMENT OF COMPENSABLE INJURIES. By Earl D. McBride, B.S., M.D., F.A.C.S. 3d ed. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1942.

A STUDY OF THE BLOOD IN CANCER; WITH SPECIAL REFERENCE TO THE NEEDS OF THE TUMOUR CLINIC. By O. Cameron Gruner, M.D. (Lond.). Montreal: Renouf Publishing Co., 1942.

AN OLD DOCTOR OF THE NEW SCHOOL. By James C. Wood, M.D. Caldwell, Idaho: The Caxton Printers, Ltd., 1942.

HISTORY OF THE SCHOOL OF NURSING OF THE PRESBYTERIAN HOSPITAL, NEW YORK, 1892–1942. By Eleanor Lee, A.B., R.N. New York: G. P. Putnam's Sons, 1942.

ACUTE INJURIES OF THE HEAD; THEIR DIAGNOSIS, TREATMENT, COMPLICATIONS AND SEQUELS. By G. F. Rowbotham, B.Sc. (Manch.), F.R.C.S. (Eng.), with a foreword by Norman M. Dott, M.B., Ch.B. (Ed.), F.R.C.S. (Ed.). Baltimore: The Williams & Wilkins Co., 1942.

ARCHITECTURAL PRINCIPLES IN ARTHRODESIS. By H. A. Brittain, M.A., M.Ch., F.R.C.S., with a foreword by Harry Platt, M.D., M.S., F.R.C.S., F.A.C.S. (Hon.). Baltimore: The Williams & Wilkins Co., 1942.

UROLOGY IN WAR; WOUNDS AND OTHER EMERGENCIES OF THE GENITO-URINARY ORGANS; SURGICAL AND MEDICAL. By Charles Y. Bidgood, Lt. Comdr. (MC) U.S.N.R. Baltimore: The Williams & Wilkins Co., 1942.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W. EDWARD GALLIE, Toronto, *President*
IRVIN ABELL, Louisville, *President-Elect*

Committee on Arrangements

WARREN H. COLE, *Chairman;* MARSHALL DAVISON, *Secretary*

1942 CLINICAL CONGRESS IN CHICAGO—A WAR SESSION

TO DEAL adequately with the many medical and surgical problems arising out of the prosecution of an all out effort to win the war, emphasizing the needs of the rapidly expanding medical services of the Army and Navy, and consideration of special problems related to the increasing activities for civilian defense, a program for the thirty-second annual Clinical Congress of the American College of Surgeons, to be held in Chicago, October 19–23, is being developed under the direction of the Board of Regents. These ideas will highlight the program for scientific sessions at headquarters and provide the basis for many clinical demonstrations at the hospitals.

The surgeons of this great medical center have organized and plan to present a program of operative clinics and demonstrations that will provide a comprehensive showing of their clinical activities in all departments of surgery at the four medical schools and some forty hospitals that will participate in the program. Under the leadership of a committee of well known surgeons, representative of the interests of all surgical specialties, a complete and varied program is assured for all who will attend this year's Congress. The five-day program will include a presentation of the latest advances in diagnostic methods, surgical technique, operative procedures, and the after-care of the surgical patient. A preliminary schedule of the clinical programs at a number of the hospitals, prepared at the direction of the Committee on Arrangements, appears in the following pages, which schedules are to be revised and amplified during the months preceding the Congress. It will be noted that clinics and demonstrations will be held at the hospitals on the afternoon of Monday, October 19, and the mornings and afternoons of each of the succeeding four days.

EXECUTIVE COMMITTEE

Warren H. Cole, Chairman	Edward L. Compere
Marshall Davison, Secretary	Sumner L. Koch
Fred L. Adair	Francis L. Lederer
George L. Apfelbach	Samuel J. Meyer
William J. Baker	Oscar E. Nadeau
Frederic A. Besley	Eric Oldberg
Alexander Brunschwig	Willard Van Hazel
James J. Callahan	John A. Wolfer

Two important features of the program for the Congress—a symposium on fractures and other traumas, and a symposium on cancer—will be presented on Tuesday and Wednesday afternoons.

PRESIDENTIAL ADDRESS—CONVOCATION

At the Presidential Meeting and Convocation, on Monday evening in the ballroom of the Stevens Hotel, the new officers of the College will be inaugurated, and the initiates received into fellowship. The new officers are: Irvin Abell, Louisville, President; Leland S. McKittrick, Boston, First Vice President; F. Phinizy Calhoun, Atlanta, Second Vice President. Distinguished surgeons from foreign countries will be introduced, following which Dr. W. Edward Gallie, of Toronto, will deliver the presidential address.

Major General James C. Magee, Surgeon General of the Army; Rear Admiral Ross T. McIntire, Surgeon General of the Navy, and Colonel George Baehr, M.C., U.S.A., Chief Medical Officer of the Office of Civilian Defense have been invited to deliver addresses at this session.

PANEL DISCUSSIONS ON WAR SURGERY

The value of the panel discussion as a medium of conveying information on selected subjects has been amply demonstrated in previous Clinical Congresses, sectional meetings, and the "war sessions" that have been held throughout the country during the present year. The Board

of Regents has deemed it wise to use this medium as the principal method for the presentation of subjects at the headquarters for the 1942 Congress. The master panels will be held on each afternoon, Monday through Friday, and on Wednesday and Thursday evenings.

The restriction of the program to subjects dealing directly with war surgery has made it desirable to arrange these panel discussions, so that they will be held consecutively rather than synchronously. This arrangement will enable all attending the Congress to be present at all of the panel discussions, as every surgeon will wish to do. They will be held in the ballroom of the Stevens Hotel, which will amply accommodate the members of the Congress.

Eminent civilian and military surgeons and physicians will collaborate in all of the panel discussions and opportunity will be afforded for questions from the floor. Among the speakers will be surgeons who have actually participated in the military services during the present war. Arrangements are being made for the discussion of the following subjects: Recognition and treatment of shock, treatment of burns, fractures, and wounds of the chest, skull, face and other soft parts.

At one of the panels especial attention will be directed to the procedures adopted by the medical corps of the Army and Navy in the transportation of the wounded and their treatment at the various types of hospitals and stations established by the military services, as well as aboard airplanes and ships.

On Tuesday evening in addition to the panel discussions, the annual oration on surgery will be delivered and certain medical aspects of the war will be presented by representatives of the federal services on the subjects of tropical medicine, acute infectious diseases, venereal disease, and gynecology and obstetrics in their relation to the war.

CLINICAL PROGRAM

The clinical programs for the hospitals and medical schools will be arranged to cover subjects in general surgery, obstetrics and gynecology, fractures and other traumas, thoracic surgery, neurosurgery, urology, orthopedic surgery, ophthalmology and otolaryngology. Under these classifications, the presentations will be so correlated that the visiting surgeon will have an opportunity to devote his time continuously to those clinics dealing with the specialty in which he is most interested. The complete detailed clinical program for each day will be posted in the form of bulletins at headquarters at the Stevens Hotel during the afternoon of the preceding day and distributed in printed form each morning.

FORUM ON FUNDAMENTAL SURGICAL PROBLEMS

A feature introduced at the 1941 Clinical Congress in Boston, where it met with great favor, was the "Forum on Fundamental Surgical Problems." It will have an important place on the program for the 1942 session. Plans are being formulated by a committee under the chairmanship of Dr. Owen H. Wangensteen of the University of Minnesota. The purpose of this forum is to enable younger men, representing various university departments of surgery, to present the important results of their clinical and experimental research work before a large surgical meeting, as heretofore there has been limited opportunity for these younger men, many of whom have not yet qualified for membership in the principal surgical societies, to present their original work and ideas. As surgery is concerned today not only with anatomy and pathology, but to a growing extent with physiology, chemistry and physics, it is felt that the Clinical Congress program will be further broadened by the presentation of the best of this material, so that the surgeons attending the Congress may benefit therefrom. Presentations of original experimental work will relate to surgery and the surgical specialties. There will be no prepared discussions but an opportunity will be afforded those in attendance to ask questions. Presentations will be limited to ten minutes each, and it is expected that some of the best examples of new and highly constructive developments in surgery will be presented. There is every indication that a live and active surgical forum in which the younger men may participate will constitute an important activity of the Congress.

SURGERY OF THE EYE, EAR, NOSE AND THROAT

The general program of the Congress includes many features of special interest to those surgeons whose practice is limited to ophthalmology and otolaryngology. In addition to extensive schedules of clinics and demonstrations in surgery of the eye, ear, nose, and throat, to be given daily at the hospitals, programs are in preparation for a series of clinical conferences on Tuesday, Wednesday and Thursday mornings at headquarters, at which subjects of timely interest to these specialists will be discussed in small groups under the leadership of outstanding men, providing an opportunity for all in attendance to ask questions and participate in the discussions. For Tuesday and Wednesday evenings programs are being prepared for scientific sessions, including

papers and symposia on pertinent subjects. Preceding each morning and evening session there will be an exhibition of selected motion picture films on subjects related to these special fields.

HOSPITAL STANDARDIZATION CONFERENCE

At the opening session of the twenty-fourth annual Hospital Standardization Conference, at 10 o'clock on Monday morning, Dr. W. Edward Gallie, of Toronto, presiding, the 1942 list of approved hospitals, cancer clinics, and hospitals approved for graduate training in surgery and the surgical specialties will be officially announced. Representatives of the Medical Corps of the Army and Navy, Office of Civilian Defense, Procurement and Assignment Service, Selective Service, and the Army Nurse Corps, are being invited to participate in this program.

The hospital conference will continue on Monday afternoon and on the mornings and afternoons of the following three days. Programs are being prepared that will be of interest to hospital administrators, heads of various hospital departments and their personnel, nurses, and members of the governing boards.

As a special feature of the conference it is planned to develop a program that will appeal to the general surgeon and surgical specialists. For some of the sessions the programs will consist of formal papers, while others will assume the nature of panel discussions, round-table conferences, and open forums. At certain sessions specific phases of a general theme will be presented by several speakers; in others a variety of subjects will be covered, the program being developed to meet current needs, emphasizing the rôle of the hospital in the program of national defense.

SCIENTIFIC EXHIBITS

Arrangements are being made for a limited display of scientific exhibits to be placed in the lounge on the second floor of the hotel, adjacent to the ballroom. The committee in charge of the exhibits is planning that they shall for the greater part illustrate subjects which will be discussed at the scientific meetings. As in the other features of the Congress, it is expected that these exhibits will have a direct bearing on surgery as practiced in wartime and on measures for civilian defense. Exhibits by various departments of the College will present what amounts to up-to-date reports on the scope and progress of the work.

GRADUATE TRAINING IN SURGERY

The College program for graduate training in surgery and the surgical specialties, as it may be affected by wartime conditions, will receive special attention at this Congress. Various phases of this important activity of the College will be presented for discussion by surgeons, hospital executives, and educators who are concerned with the future standard of surgery in the United States and Canada. A program dealing with various types of educational programs will be presented, followed by a general discussion from the floor.

MEDICAL MOTION PICTURES

An enlarged program of surgical motion pictures will be presented daily at headquarters and will include the latest available films on a wide variety of subjects of interest to the surgeon—both sound and silent, standard and color films, that have been approved by the Committee on Medical Motion Pictures, will be presented.

PUBLICATION OF PROCEEDINGS

As in former years, the papers which are presented at the scientific sessions of the Congress will be published in a special issue of the official journal of the College, SURGERY, GYNECOLOGY AND OBSTETRICS, in February following the meeting. This is furnished without additional charge to all fellows, junior candidates, and others who register for the Congress as invited guests. The papers which are presented in connection with the Hospital Standardization Conference will be published in subsequent issues of the *Bulletin of the American College of Surgeons*.

ADVANCE REGISTRATION

The hospitals and medical schools of the Chicago area afford accommodations for a large number of visiting surgeons, but to insure against overcrowding, attendance at the Congress will be limited to the number that can be comfortably accommodated at the clinics. The limit of attendance will be based on a survey determining the available facilities in the participating hospitals and schools. It is expected, therefore, that surgeons who wish to attend the Congress will register in advance.

As in previous years, admission to clinics and demonstrations in the hospitals and certain of the scientific meetings at headquarters will be controlled by means of tickets. This plan provides for the distribution of visiting surgeons at the various clinics and other meetings and helps to insure against overcrowding. The number of tickets issued for any clinic will be limited to the capacity of the room in which the clinic is held. Visiting surgeons are urged to co-operate in making the clinic ticket plan a success.

REGISTRATION FEES

Resolutions adopted by the Board of Regents provide that no registration fee for the 1942 Clinical Congress, is to be paid by fellows of the College including initiates of the class of 1942. The fee for endorsed junior candidates is $5.00 and for surgeons, not fellows, attending as invited guests of the College, $10.00. For purposes of identification at the registration desk fellows will present their fellowship cards.

When the registration fee is paid in advance a formal receipt will be issued to the surgeon so registering, which is to be exchanged for a general admission card upon presentation at headquarters during the Congress. This card is not transferable and must accompany all requests for clinic tickets and be presented for admission to scientific sessions when required.

HEADQUARTERS—TECHNICAL EXHIBITION

Headquarters for the Congress will be established at the Stevens Hotel, which affords unusual facilities for accommodating the Congress. All the public rooms on the second and third floors and ballrooms in the tower have been reserved for scientific sessions, panel discussions, conferences, and scientific exhibits. Thus all activities of the Congress, except the clinics at the hospitals, will be held in one building.

The technical exhibition, together with the registration and clinic ticket desk, will be located on the lower floor of the hotel in the large exhibition hall, where the daily clinical program will be posted in the form of bulletins. Leading manufacturers of surgical instruments and supplies, sutures, dressings, pharmaceuticals, operating room equipment, x-ray apparatus and hospital equipment of all kinds, as well as publishers of medical books will be represented in the exhibition. It will provide for the visiting surgeons an opportunity of carefully inspecting the finest modern products of all those industries which are aiding the work of the surgeon and the hospital.

CHICAGO HOTELS AND THEIR RATES

In addition to the headquarters hotel, the Stevens, there are several first-class hotels within walking distance of headquarters, providing ample hotel facilities at reasonable rates. It is suggested that reservation of hotel accommodations be made at an early date. The following hotels are recommended by the Committee:

	Minimum rate with bath	
	Single	Double
Bismarck, 171 W. Randolph St.	$3.75	$5.25
Blackstone, Michigan Ave. at 7th St.	4.00	7.00
Congress, 500 S. Michigan Ave.	3.00	5.00
Drake, Michigan and Lake Shore Drive.	4.00	6.00
Harrison, 57 E. Harrison St.	2.00	3.00
LaSalle, 10 N. LaSalle St.	2.75	4.40
Morrison, 79 W. Madison St.	2.75	4.40
Palmer House, 15 E. Monroe St.	3.85	5.50
Sherman, 106 W. Randolph St.	2.75	4.40
Stevens, 720 S. Michigan Ave.	3.25	4.75

PRELIMINARY CLINICAL PROGRAM

COOK COUNTY HOSPITAL

Monday

GENERAL SURGERY

RICHARD H. LAWLER—2. Operative clinic.

OBSTETRICS AND GYNECOLOGY

A. F. LASH—1. Operative clinic: Gynecological.

FRACTURES AND OTHER TRAUMAS

WILLIAM R. CUBBINS, JAMES J. CALLAHAN, and CARLO S. SCUDERI—1. Operative clinic.

ORTHOPEDIC SURGERY

E. J. BERKHEISER—2. Dry clinic.

NEUROSURGERY

HAROLD C. VORIS—1. Operative clinic.

OTOLARYNGOLOGY

JACOB LIFSCHUTZ—2. Operative and dry clinic.

Tuesday

GENERAL SURGERY

GEORGE G. DAVIS—8. Operative clinic.
KARL A. MEYER and RAYMOND W. MCNEALY—9. Operative clinic.
SUMNER L. KOCH—9. Dry clinic: Injuries of the upper extremities.
JOHN D. KOUCKY—10. Operative clinic.
JOHN R. HARGER—10. Operative clinic.
EDWIN M. MILLER and E. H. FELL—10. Dry clinic.
JOHN B. O'DONOGHUE—11. Operative clinic.
RALPH B. BETTMAN—2. Operative clinic.
PETER A. ROSI—2. Operative clinic: Large bowel and rectum.
E. H. WARSZEWSKI—3. Operative clinic.

COOK COUNTY GRADUATE SCHOOL OF MEDICINE

Staff—12:30. Demonstration on cadaver, some principles in gall-bladder surgery.

OBSTETRICS AND GYNECOLOGY

WILLIAM T. CARLISLE—9. Operative clinic: Gynecological.
A. E. KANTER—11. Operative clinic: Gynecological.
J. P. GREENHILL—1. Operative clinic: Gynecological.

ORTHOPEDIC SURGERY

ARTHUR H. CONLEY—9. Operative clinic.
MARCUS H. HOBART—10. Operative clinic: Knee operation.

OPHTHALMOLOGY

EDWARD A. ROLING—9. Operative clinic.

Wednesday

GENERAL SURGERY

WILLIAM M. MCMILLAN—8. Operative clinic.
E. A. CHRISTOFFERSON—9. Dry clinic.
FRANK J. JIRKA—10. Dry clinic: Human bites of the hand.
ROGER T. VAUGHAN—10. Operative clinic.
JACOB R. BUCHBINDER—1. Operative clinic.
Staff—2. Symposium: Traumatic surgery.
SUMNER L. KOCH. Treatment of fresh accidental wounds.
WILLIAM R. CUBBINS. Management of compound fractures.
HARRY A. OBERHELMAN. Gunshot wounds of the abdomen.
ADRIEN VERBRUGGHEN. Management of acute head injuries.
LINDON SEED. Gunshot wounds of the chest.
HUGH O. BROWN. Anesthesia under wartime conditions.

COOK COUNTY GRADUATE SCHOOL OF MEDICINE

Staff—12:30. Demonstrations in gastric surgery on the cadaver and anesthetized dog.

OBSTETRICS AND GYNECOLOGY

HERBERT E. SCHMITZ—9. Operative clinic: Gynecological.
A. F. LASH—11. Operative clinic: Gynecological.
DAVID S. HILLIS, JAMES H. BLOOMFIELD, JAMES E. FITZGERALD, LOUIS RUDOLPH, ALFRED J. KOBAK, and AUGUST DARO—1. Obstetrical operations and discussion; cephalopelvic disproportion in 1000 consecutive cases.

FRACTURES AND OTHER TRAUMAS

JAMES J. CALLAHAN—8. Ward walk.
GEORGE L. APPELBACH—10. Operative clinic.

ORTHOPEDIC SURGERY

PHILIP LEWIN—9. Operative clinic.
DANIEL H. LEVINTHAL and associates—9. Dry clinic.
DANIEL H. LEVINTHAL and associates—2. Operative clinic.

GENITOURINARY SURGERY

HARRY C. ROLNICK and ANDREW MCNALLY—8. Operations.
HARRY CULVER and DORRIN F. RUDNICK—9. Operations.

NEUROSURGERY

HAROLD C. VORIS—9. Dry clinic.
ADRIEN VERBRUGGHEN—1. Operative clinic.

OPHTHALMOLOGY

WILLIAM F. MONCREIFF—9. Operative clinic.

OTOLARYNGOLOGY

JACOB LIFSCHUTZ—2. Operative clinic.

Thursday

GENERAL SURGERY

HARRY A. OBERHELMAN—8. Operative clinic.
MAX THOREK—9. Operative clinic.
MARSHALL DAVISON—10. Operative clinic.
JOSEPH E. SCHAEFER—10. Operative clinic.
Staff—11. Clinical pathological conference.
E. J. LEWIS—1:30. Operative clinic.

COOK COUNTY GRADUATE SCHOOL OF MEDICINE

RAYMOND W. MCNEALY—11. Lecture on femoral hernia.

OBSTETRICS AND GYNECOLOGY

E. W. FISCHMANN—9. Operative clinic.

FRACTURES AND OTHER TRAUMAS

JAMES J. CALLAHAN—8. Ward walk.
WILLIAM R. CUBBINS—1. Operative clinic.

ORTHOPEDIC SURGERY

ARTHUR H. CONLEY—10. Dry clinic.
E. J. BERKHEISER—2. Operative clinic.

THORACIC SURGERY

RALPH B. BETTMAN—2. Operative clinic.

NEUROSURGERY

ADRIEN VERBRUGGHEN—11. Dry clinic.

Friday

GENERAL SURGERY

RALPH C. SULLIVAN—8. Operative clinic.
EDWIN M. MILLER—8. Operative clinic.
LOUIS P. RIVER—9. Operative clinic.
ALBERT H. MONTGOMERY—10. Operative clinic.

OBSTETRICS AND GYNECOLOGY

WILLIAM H. BROWNE—9. Operative clinic.
FREDERICK H. FALLS—10. Operative clinic.

FRACTURES AND OTHER TRAUMAS

JAMES J. CALLAHAN—8. Ward walk.

COOK COUNTY GRADUATE SCHOOL OF MEDICINE

Staff—12:30. Demonstrations on cadaver, fractures and traumatic surgery.

THORACIC SURGERY

RICHARD M. DAVISON—8. Operative clinic.

NEUROSURGERY

HAROLD C. VORIS—1. Operative clinic.

OPHTHALMOLOGY

SANFORD R. GIFFORD—9. Operative clinic.

OTOLARYNGOLOGY

THOMAS C. GALLOWAY—9. Dry clinic: Anaerobic infections about the head with special reference to osteomyelitis.
THOMAS C. GALLOWAY, JACOB LIFSCHUTZ, and HAROLD E. DAVIS—10. Dry clinic: Malignancies of head and neck.

CHILDREN'S MEMORIAL HOSPITAL

Tuesday

ORTHOPEDIC SURGERY

F. A. CHANDLER, FERDINAND SEIDLER, C. N. PEASE, and M. A. PAGE—9. Operations: Shelf operation for congenital dislocation of the hip; extraperitoneal resection of the obturator nerve; stabilization of pronated foot; torticollis in the newborn; patellar advancement operations.

Wednesday

GENERAL SURGERY

ALBERT H. MONTGOMERY, JAY IRELAND, WILLIS J. POTTS, J. J. MUSSIL, and STANLEY E. LAWTON—9. Operations and demonstrations.

Thursday

GENITOURINARY SURGERY

KNOWLTON E. BARBER—9. Operations and demonstrations.

MICHAEL REESE HOSPITAL

Monday

GENERAL SURGERY

Staff—2. Symposium: Shock, transfusion, blood substitutes and allied problems.

Tuesday

GENERAL SURGERY

Staff—9. Operative clinic.
Staff—9. Symposium: Gastrointestinal surgery.
Staff—2. Symposium: Peripheral circulatory diseases and surgery of the diabetic patient.

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic: Gynecological.

GENITOURINARY SURGERY

Staff—9. Dry clinic.

ORTHOPEDIC SURGERY

Staff—9. Operative clinic.

Wednesday

GENERAL SURGERY

Staff—9. Operative clinic.
Staff—9. Symposium: Biliary tract diseases.
Staff—2. Dry clinic: General surgical problems.

OBSTETRICS AND GYNECOLOGY

Staff—9. Dry clinic: Obstetrical and gynecological.

ORTHOPEDIC SURGERY

Staff—2. Dry clinic: Fractures, reconstructive surgery and allied problems.

GENITOURINARY SURGERY

Staff—9. Operative clinic.

Thursday

GENERAL SURGERY

Staff—9. Operative clinic.
Staff—9. Symposium: Thyroid.
Staff—2. Dry clinic: General surgical problems.

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic.

GENITOURINARY SURGERY

Staff—9. Operative clinic.

ORTHOPEDIC SURGERY

Staff—9. Operative clinic.

THORACIC SURGERY

Staff—9. Operative and dry clinic: Progress in thoracic surgery.

NEUROSURGERY

Staff—2. Symposium: Cerebral traumas and other neurosurgical problems.

Friday

GENERAL SURGERY

Staff—9. Operative clinic.

RESEARCH AND EDUCATIONAL HOSPITALS

Monday

GENERAL SURGERY

ERIC OLDBERG—2. Dry clinic.

Tuesday

GENERAL SURGERY

GÉZA DE TAKATS and associates—9. Operative and dry clinic: Splanchnic nerve section for hypertension. Symposium on surgery of the autonomic nervous system: Results of sympathectomy in Raynaud's disease and Buerger's disease; sympathectomy for megacolon; sympathectomy for retinitis pigmentosa; indications and technique for denervating the carotid sinus; results of splanchnic nerve section in hypertension; demonstration of renal biopsies and their correlation with clinical findings in hypertension.

THORACIC SURGERY

WILLARD VAN HAZEL and C. IRENEUS—9. Operative and dry clinic.

NEUROSURGERY

PAUL C. BUCY—2. Operative and dry clinic.

OPHTHALMOLOGY

HALLARD BEARD—9. "Garden variety" eye operations, illustrated in moving pictures.

OTOLARYNGOLOGY

PAUL H. HOLINGER and A. H. ANDREWS, JR.—9. Bronchoscopic clinic.
F. L. LEDERER and staff—2. Operations.

Wednesday

GENERAL SURGERY

WARREN H. COLE and staff—9. Operative clinic: Thyroid gland; peptic ulcer.
PAUL W. GREELEY—9. Operations: Plastic.

OBSTETRICS AND GYNECOLOGY

FREDERICK H. FALLS, W. H. BROWNE, R. A. LIFVENDAHL, and A. F. LASH—2. Operative and dry clinic.

ORTHOPEDIC SURGERY

H. B. THOMAS and staff—2. Operative clinic: Exploration of knee; lumbosacral spinal fusion.

GENITOURINARY SURGERY

C. M. MCKENNA, J. H. KIEFER, and R. D. HERROLD—9. Operative and dry clinic.

NEUROSURGERY

ERIC OLDBERG—9. Operative and dry clinic.

OTOLARYNGOLOGY

F. L. LEDERER—4. Otolaryngological seminar.

Thursday

GENERAL SURGERY

CHARLES B. PUESTOW and staff—9. Operations: Biliary tract.

ORTHOPEDIC SURGERY

H. B. THOMAS and staff—2. Operative clinic: Malunited fractures; operative correction of slipped femoral epiphyses.

NEUROSURGERY

W. A. GUSTAFSON—9. Operative and dry clinic.

OTOLARYNGOLOGY

F. L. LEDERER—2. Operative and dry clinic.

Friday

GENERAL SURGERY

R. B. MALCOLM—9. Operative and dry clinic: Surgery of the neck.
PAUL W. GREELEY—9. Follow-up clinic on plastic surgery.
LOUIS W. SCHULTZ—9. Operations: Cleft lip and palate.

OBSTETRICS AND GYNECOLOGY

FREDERICK H. FALLS, W. H. BROWNE, R. A. LIFVENDAHL, and A. F. LASH—2. Operative and dry clinic.

NEUROSURGERY

PERCIVAL BAILEY—9. Operative and dry clinic.

ILLINOIS EYE AND EAR INFIRMARY

Monday

OTOLARYNGOLOGY

SAMUEL SALINGER—2. Dry clinic: Cases involving plastic reconstruction of nose and face.

Tuesday

OPHTHALMOLOGY

THOMAS D. ALLEN—2. Operative clinic: Glaucoma.
GLENWAY W. NETHERCUT and VERNON M. LEECH—2. Operative clinic: Cataract.

OTOLARYNGOLOGY

M. A. GLATT—2. Operative clinic.
EDWIN J. BLONDER—2. Operative clinic: Radical mastoidectomy.
ALFRED LEWY—2. Dry clinic.

Wednesday

OPHTHALMOLOGY

PHILIP D. O'CONNOR—2. Dry clinic: Some problems of surgery of the eyelids, lantern demonstration.

Thursday

OPHTHALMOLOGY

LOUIS G. HOFFMAN—9. Dry clinic.

OTOLARYNGOLOGY

M. A. GLATT—2. Dry clinic: End-results of sinus surgery.
C. H. CHRISTOPH—2. Operative and dry clinic: Radical mastoid.
EDWIN J. BLONDER—2. Dry clinic.

Friday

OPHTHALMOLOGY

SAMUEL J. MEYER—2. Operative clinic: Cataract and glaucoma.

WESLEY MEMORIAL HOSPITAL

Monday

GENERAL SURGERY

WILLIAM A. HENDRICKS—2. Cancer clinic.

FRACTURES AND OTHER TRAUMAS

ONIS H. HORRALL—2. Ununited fracture humerus; open reduction os calcis.

Tuesday

GENERAL SURGERY

GUY S. VAN ALSTYNE—10. Cholecystectomy.
W. M. MCMILLAN—11. Operative clinic: Gall-bladder disease.
HAYDEN E. BARNARD—2. Operative clinic: Cholecystectomy; appendectomy.
SAMUEL J. FOGELSON—2. Duodenal ulcer.

OBSTETRICS AND GYNECOLOGY

MARK T. GOLDSTINE—9. Operative and dry clinic: Gynecological.

THORACIC SURGERY

JEROME R. HEAD—2. Thoracoplasty.

Wednesday

GENERAL SURGERY

EARL O. LATIMER—10. Gastric resection.

FRACTURES AND OTHER TRAUMAS

PHILIP H. KREUSCHER and R. J. BENNETT—8. Open reduction of hip, Lorenz screw arthroplasty of hip, vitallium cup; recurrent dislocation of shoulder, Nicola operation.
R. T. MCELVENNY—11. Dry clinic: Certain factors influencing end-results in treatment of intracapsular and intertrochanteric femoral fractures, with lantern slides.

ORTHOPEDIC SURGERY

PAUL B. MAGNUSON—2. Demonstration: Plastics on the hip.

Thursday

GENERAL SURGERY

RAYMOND W. MCNEALY—9. Gall-bladder and stomach cases.
EARL O. LATIMER—10. Inguinal hernia repair.
NORMAN G. PARRY—2. Breast amputation.

ORTHOPEDIC SURGERY

HAMPAR KELIKIAN—2. Arthritis; arthroplasty of knee.

GENITOURINARY SURGERY

DONALD K. HIBBS—11. Suprapubic prostatectomy.

OTOLARYNGOLOGY

JOSEPH E. SCHAEFER—2. Plastic of mandible; cleft palate.

Friday

GENERAL SURGERY

PHILIP SHAMBAUGH—9. Operative clinic: Gall-bladder, appendectomy, hernia repair.

OBSTETRICS AND GYNECOLOGY

ROCCO A. MASESSA—9. Dry clinic: Cesarean operation.

FRACTURES AND OTHER TRAUMAS

EDWARD L. COMPERE—9. Management of compound fractures.

GENITOURINARY SURGERY

VICTOR D. LESPINASSE—2. Urological clinic.

GRANT HOSPITAL

Tuesday

GENERAL SURGERY

A. G. ZIMMERMAN—9. Operations.
M. H. STREICHER—9. Intestinal anastomosis and rectal surgery.
JOHN R. ORNDORFF and B. H. ORNDORFF—9. Operations: General and tumor.

Wednesday

GENERAL SURGERY

KARL A. MEYER—9. Operations.

Thursday

FRACTURES AND OTHER TRAUMAS

GEORGE L. APFELBACH—9. Open reduction of fractures.

GENITOURINARY SURGERY

WILLIAM H. GEHL—9. Dry clinic.
EDWARD F. HESS—9. Dry clinic.

OTOLARYNGOLOGY

GEORGE F. DENNIS—9. Operations.

Friday

OBSTETRICS AND GYNECOLOGY

FREDERICK H. FALLS—9. Operations: Gynecological.
E. W. FISCHMANN—9. Operations: Gynecological.

OPHTHALMOLOGY

OSCAR H. KRAFT—9. Operations.
B. T. HOFFMAN—9. Operations.

OTOLARYNGOLOGY

CARROLL W. STUART—9. Operations.

LORETTO HOSPITAL

Tuesday

GENERAL SURGERY

L. F. PLZAK. Shock and hemorrhage.
A. E. STEWART. Abdominal surgery.
T. J. ECHERER. Traumatic abdomen.
E. P. VAUGHAN. Pelvic surgery.
J. A. VALENTINE. Head injuries.
J. H. THOMAS. Injuries of extremities.
O. M. WALTER. Biliary surgery.

OBSTETRICS AND GYNECOLOGY

H. T. LITTLE. Operation: Vaginal hysterectomy.

GENITOURINARY SURGERY

C. C. SAELHOF. Traumatic injury of genitourinary tract.

NEUROSURGERY

F. M. SYLVESTER. Brain and spinal cord injuries.

ST. LUKE'S HOSPITAL

Monday

GENERAL SURGERY

J. S. COULTER—1. Physical and occupational therapy in practice.

FRACTURES AND OTHER TRAUMAS

J. D. ELLIS—2. Diagnosis of compression fractures of spine.
E. W. RYERSON—3. Shelf operations for dysplastic hip joints.
J. D. ELLIS and LAURENCE M. MARSH—4. Complicated fractures, lower end of radius.

OPHTHALMOLOGY

J. W. MARRON—2. Operative and dry clinic.

Tuesday

GENERAL SURGERY

PAUL W. GREELEY—9. Operations: Plastic.
E. L. JENKINSON—1. Stellate impression of the lower end of the esophagus.
H. E. MOCK, SR., and associates—2. Infectious granulomas of the gastrointestinal tract.
SELIM W. MCARTHUR—3. Errors in gastric diagnosis.
H. E. JONES—4. Venous mesenteric thrombosis.

OBSTETRICS AND GYNECOLOGY

H. O. JONES and associates—8. Operations: Gynecological.

NEUROSURGERY

ERIC OLDBERG—1. Operative clinic.

OPHTHALMOLOGY

EARL H. MERZ—1. Operative and dry clinic.

Wednesday

GENITOURINARY SURGERY

HARRY CULVER and T. P. GRAUER—8. Genitourinary procedures.

OPHTHALMOLOGY

JOHN J. WALSH—1. Operative and dry clinic.

OTOLARYNGOLOGY

PAUL H. HOLINGER and A. H. ANDREWS, JR.—8. Bronchoscopic procedures.
H. R. LYONS and WALTER H. THEOBALD—2. Operative and dry clinic.

Thursday

GENERAL SURGERY

GÉZA DE TAKATS and associates—8. Dry clinic: Saphenous vein ligation, indication and technique, demonstration of patients; traumatic aneurysms; aneurysms of the aorta, wiring, paravertebral alcohol injections, parasternal decompression; Sudeck's atrophy, frequent and important cause of disability following trauma; diagnosis and treatment of sudden arterial and venous occlusions, embolectomy, thrombectomy, sympathetic block, studies on heparin.
PAUL W. GREELEY—9. Operations: Plastic.

NEUROSURGERY

ERIC OLDBERG—2. Operations.

OPHTHALMOLOGY

FRANK BRAWLEY and JAMES W. CLARK—2. Eye clinic.
LOUIS BOTHMAN—3. Fundus diseases: Kodachrome clinic.

Friday

GENERAL SURGERY

Staff—9. Surgical rounds with weekly hospital clinics.
H. E. MOCK, SR., H. E. MOCK, JR., and WILFRED A. MAJOR—10. Peripheral circulatory diseases of the extremities; refrigeration anesthesia in amputations.
W. A. CONROY and associates—1. Anesthesia procedures.

OPHTHALMOLOGY

RICHARD GAMBLE—1. Eye clinic.

MERCY HOSPITAL

Tuesday

GENERAL SURGERY

JOHN KEELEY, CHARLES F. SAWYER, MICHAEL F. MCGUIRE, HARRY A. OBERHELMAN, and ARKELL K. VAUGHN—9. Operative clinics: Traumatic and general surgery.

Wednesday

OBSTETRICS AND GYNECOLOGY

HERBERT E. SCHMITZ and associates—9. Operative clinic: Gynecological.
WILLIAM T. CARLISLE and associates.—9 Operative clinic: Gynecological.

Thursday

GENERAL SURGERY

CLEMENT L. MARTIN—9. Operations: Proctological.

ORTHOPEDIC SURGERY

JOHN D. CLARIDGE—9. Operations.

GENITOURINARY SURGERY

HERBERT E. LANDES—9. Operations.

NEUROSURGERY

HAROLD C. VORIS—9. Operations.

HENROTIN HOSPITAL

Days to be Announced

GENERAL SURGERY

JOHN A. GRAHAM. Surgical clinic.
O. E. VAN ALYEA. Applied anatomy of nasal sinuses.
E. L. CORNELL. Simplified wartime technique for delivery room.
JOHN R. WOLFF. Treatment of postpartum hemorrhage.
F. LEE STONE. Sterility.
A. M. BRAND. Rôle of the male in abortions.
E. L. CORNELL. Bilateral fracture and dislocated shoulder in eclampsia.

PASSAVANT MEMORIAL HOSPITAL

Monday

ORTHOPEDIC SURGERY

EMIL D. W. HAUSER—3:30. Operations.

Tuesday

GENERAL SURGERY

J. R. BUCHBINDER—9. Operations.
HARRY M. RICHTER—9. Operations.
JOHN A. WOLFER—9. Operations.

OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9. Operations.

ORTHOPEDIC SURGERY

PAUL B. MAGNUSON—2. Operations.
JAMES K. STACK—2. Operations.
EMIL D. W. HAUSER—3:30. Operations.

GENITOURINARY SURGERY

KNOWLTON E. BARBER—9. Operations.

Wednesday

GENERAL SURGERY

J. R. BUCHBINDER—9. Operations.
SUMNER L. KOCH—9. Operations.

OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9. Operations.
GEORGE H. GARDNER—9. Operations.

GENITOURINARY SURGERY

KNOWLTON E. BARBER—9. Operations.

NEUROSURGERY

LOYAL DAVIS—9. Operations.

Thursday

GENERAL SURGERY

J. R. BUCHBINDER—9. Operations.
HARRY M. RICHTER—9. Operations.
JOHN A. WOLFER—9. Operations.

ORTHOPEDIC SURGERY

EMIL D. W. HAUSER—3:30. Operations.

Friday

GENERAL SURGERY

J. R. BUCHBINDER—9. Operations.
SUMNER L. KOCH—9. Operations.

OBSTETRICS AND GYNECOLOGY

ARTHUR H. CURTIS—9. Operations.
GEORGE H. GARDNER—9. Operations.

NEUROSURGERY

LOYAL DAVIS—9. Operations.

SWEDISH COVENANT HOSPITAL

Wednesday

GENERAL SURGERY

R. F. ELMER and W. B. STROMBERG—8:30. Abdominal surgery.

OBSTETRICS AND GYNECOLOGY

R. A. LIFVENDAHL, G. F. HIBBERT, and HARRIS J. TIMERMAN—8:30. Operations: Gynecological.

FRACTURES AND OTHER TRAUMAS

O. T. ROBERG—8:30. Operative and dry clinic.

GENITOURINARY SURGERY

JOHN T. GERNON—8:30. Operations.

ILLINOIS MASONIC HOSPITAL

Tuesday

GENERAL SURGERY

Staff—8. Operative clinic:
W. C. BORNEMEIER and I. KROSS—8. Partial gastrectomy.
C. OTIS RITCH—8. Cystotomy.
R. B. GAINES—9. Cystoscopy and pyelogram.
J. F. DAVIS and A. E. WUESTEMAN—9. Cholecystostomy.
WILBUR E. KEESEY and O. HARRIS—10. Colectomy for carcinoma of the cecum.
EDWARD W. WHITE—10. Nephrectomy.
T. G. WALLIN and BEULAH WALLIN—11. Radical mastectomy.
R. BRUCE MALCOLM and J. WALTER JOHNSON—12. Abdominal perineal resection.
PHILIP SHAMBAUGH—12. Common duct stone.

OBSTETRICS AND GYNECOLOGY

F. O. BOWE—8. Operation: Cesarean section.
H. W. MILLER and GLENN S. NELSON—9. Operation: Hysterectomy.
W. E. PUGH and A. U. DERMAN—10. Operation: Ovarian cyst.

GENITOURINARY SURGERY

WILLIAM H. GEHL and F. L. CHENOWETH—11. Transurethral resection.
C. C. SAELHOF—12. Prostatectomy.

THORACIC SURGERY

MINAS JOANNIDES—12. Thoracotomy.

NEUROSURGERY

W. A. GUSTAFSON—11. Subtemporal decompression.

Wednesday

GENERAL SURGERY

ARTHUR H. GEIGER—11. Operation: Tonsillectomy and adenoidectomy.
CHARLES J. DRUECK and H. E. OLIVER—12. Hemorrhoidectomy.

OBSTETRICS AND GYNECOLOGY

DANIEL W. JEFFRIES—9. Perineorrhaphy.

ORTHOPEDIC SURGERY

WALTER R. FISCHER—10. Tenotomy.
CHARLES N. PEASE—11. Fixation of fracture of hip.

OPHTHALMOLOGY

ALVA SOWERS—10. Operation: Cataract.

OTOLARYNGOLOGY

H. E. TAYLOR—8. Submucous resection.
M. H. COTTLE and R. LORING—9. Radical mastoidectomy.

ALBERT MERRITT BILLINGS HOSPITAL

Tuesday

GENERAL SURGERY

WILLIAM E. ADAMS, L. R. DRAGSTEDT, ALEXANDER BRUNSCHWIG, and CHARLES B. HUGGINS—9. Operative clinics.

Wednesday

GENERAL SURGERY

L. R. DRAGSTEDT, CHARLES B. HUGGINS, DALLAS B. PHEMISTER, and CLY H. HATCHER—9. Operative clinics.

Thursday

GENERAL SURGERY

WILLIAM E. ADAMS, ALEXANDER BRUNSCHWIG, A. EARL WALKER, and HILGER P. JENKINS—9. Operative clinics.

Friday

GENERAL SURGERY

DALLAS B. PHEMISTER, L. R. DRAGSTEDT, ALEXANDER BRUNSCHWIG, and CLY H. HATCHER—9. Operative clinics.

JACKSON PARK HOSPITAL

Tuesday

GENERAL SURGERY

A. BAMBERGER—9. Operations.
C. C. CLARK—9. Operations: Abdominal.

FRACTURES AND OTHER TRAUMAS

FRANK G. MURPHY—9. Fracture cases.

GENITOURINARY SURGERY

S. J. SULLIVAN—9. Operations.

Wednesday

GENERAL SURGERY

H. H. COX—9. Operations.
W. M. SHERIN—9. Gall-bladder operations.
A. BAMBERGER—10. Head injuries.

GENITOURINARY SURGERY

WILLIAM YONKER—9. Operations.

Thursday

GENERAL SURGERY

NOAH FOX—8. Plastic surgery of the face.
DAVID S. JAFFRAY—10. Operations.
A. BAMBERGER—10. Abdominal injuries.
S. J. SULLIVAN, F. G. MURPHY, NOAH FOX, H. H. COX, and A. BAMBERGER—12. Symposium: Traumatic surgery.

OBSTETRICS AND GYNECOLOGY

L. H. STERN and CHARLES F. GREENE—8. Operations.

Friday

GENERAL SURGERY

A. BAMBERGER—9. Operation: Thyroid.
C. C. CLARK—9. Operations.
H. H. COX—9. Operations.

NORWEGIAN-AMERICAN HOSPITAL

Friday

GENERAL SURGERY

Staff—9. Dry clinic:
J. M. AMBERSON—9. Blood and plasma in surgery.
G. B. FAULEY—9:15. Peptic ulcer, modern concepts.
A. M. JENSEN—9:30. Sulfanilamide in general surgery.
J. R. ORNDORFF—9:45. Common duct surgery.
F. H. FOWLER—10. Perforative appendicitis.
J. V. FOWLER, JR.—10:15. Thyroid gland surgery.
J. E. VERHAAG—10:30. Hernia from industrial causes.
H. R. FISHBACK—10:40. Tumor clinic, selected cases.
B. A. FINNE—10:45. Gall-bladder surgery, nutritional aspects.
WARREN JOHNSON—11. Carcinoma of the stomach.
F. M. NICHOLSON—11:15. Scalp injuries.
M. E. LICHTENSTEIN—11:30. Operating room decorum.
J. V. FOWLER, SR.—11:45. Carcinoma of the breast.

OBSTETRICS AND GYNECOLOGY

Staff—9. Dry clinic:
B. W. BREISTER—9. Toxemias of pregnancy.
P. F. SNYDER—9:20. Uterine tumors, differential diagnosis.
I. C. UDESKY—9:40. Indications for use of forceps.

GENITOURINARY SURGERY

D. F. RUDNICK—10. Transurethral resection of the prostate.

FRACTURES AND OTHER TRAUMAS

M. M. CORBETT—10:20. Immediate treatment for fracture of the long bones.

OTOLARYNGOLOGY

M. A. GLATT—11:20. Tonsillectomy, control of hemorrhage.
J. W. HARNED—11:40. Mastoid infection, danger signals.

WOMEN AND CHILDREN'S HOSPITAL

Tuesday

GENERAL SURGERY

MARY E. WILLIAMS—9. Operations.
EMELIA J. GIRYOTAS—10:30. Operations.

OBSTETRICS AND GYNECOLOGY

ELOISE PARSONS—2. Operations: Gynecological.

Wednesday

GENERAL SURGERY

PEARL M. STETLER—9. Operations.

Thursday

OBSTETRICS AND GYNECOLOGY

BERTHA VAN HOOSEN—9. Operations: Obstetrical.
BERTHA VAN HOOSEN—10. Moving pictures showing technique of pubiotomy and demonstration of patients.
MAUDE H. WINNETT—10:30. Operations: Gynecological.
BEATRICE E. TUCKER—2. Operations: Obstetrical.

Friday

GENERAL SURGERY

KATHERINE K. TRUE—9. Operations.

SCIENTIFIC EXHIBIT

Demonstration of emergency medical field unit.

PRESBYTERIAN HOSPITAL

Tuesday

GENERAL SURGERY

VERNON C. DAVID, CARL B. DAVIS, KELLOGG SPEED, ALBERT H. MONTGOMERY, and HILLIER L. BAKER—9. Operations.

GENITOURINARY SURGERY

HERMAN L. KRETSCHMER and associates—9. Operations.

Wednesday

GENERAL SURGERY

VERNON C. DAVID, CARL B. DAVIS, KELLOGG SPEED, ALBERT H. MONTGOMERY, and HILLIER L. BAKER—9. Operations.

OBSTETRICS AND GYNECOLOGY

A. E. KANTER—9. Prolapse operation.
N. SPROAT HEANEY—9. Operation: Vaginal hysterectomy for fibroids.
EDWARD C. ALLEN—9. Vaginal sterilization.
FRED O. PRIEST—9. Operations: Gynecological.

Thursday

GENERAL SURGERY

VERNON C. DAVID, CARL B. DAVIS, KELLOGG SPEED, ALBERT H. MONTGOMERY, HILLIER L. BAKER—9. Operations.

OBSTETRICS AND GYNECOLOGY

A. E. KANTER—9. Prolapse operation.
N. SPROAT HEANEY—9. Operation: Vaginal hysterectomy for fibroids.
EDWARD C. ALLEN—9. Vaginal sterilization.
FRED O. PRIEST—9. Operations: Gynecological.

Friday

OBSTETRICS AND GYNECOLOGY

A. E. KANTER—9. Prolapse operation.
N. SPROAT HEANEY—9. Operation: Vaginal hysterectomy for fibroids.
EDWARD C. ALLEN—9. Vaginal sterilization.
FRED O. PRIEST—9. Operations: Gynecological.

CHICAGO MEMORIAL HOSPITAL

Monday

GENERAL SURGERY

Staff—2. Panel discussion: Hospital care of civilian defense casualties.

Tuesday

GENERAL SURGERY

Staff—9. Operations.
Staff—2. Symposium: Traumatic surgery, by the surgical, orthopedic and neurosurgical staffs.

Wednesday

GENERAL SURGERY

Staff—9. Operations.
Staff—2. Dry clinics.

Thursday

GENERAL SURGERY

Staff—9. Operations.

MUNICIPAL TUBERCULOSIS SANITARIUM

Tuesday

GENERAL SURGERY

CLEMENT L. MARTIN—9. Anorectal conditions.

ORTHOPEDIC SURGERY

J. R. NORCROSS—2. Operations.

OTOLARYNGOLOGY

GEORGE HOLMES—2. Dry clinic: Bronchoscopy.

Wednesday

GENERAL SURGERY

LEO L. HARDT—9. Dry clinic: Gastroscopy.

Thursday

THORACIC SURGERY

RICHARD M. DAVISON—9. Operations.

OTOLARYNGOLOGY

S. H. SOBOROFF—2. Tuberculosis of larynx.

Friday

GENITOURINARY SURGERY

D. F. RUDNICK—9. Dry clinic.

ST. JOSEPH HOSPITAL

Monday

GENERAL SURGERY

WILLIAM E. ANSPACH—2. Radiologic demonstration.

Tuesday

GENERAL SURGERY

HUGH MCKENNA—9. Dry clinic: Surgical management of intestinal obstruction associated with malignancy of colon; review fractures neck of femur.

Wednesday

GENERAL SURGERY

FRANKLIN B. MCCARTY—10. Operations.
J. A. WIMBERLY—11. Operations.

GENITOURINARY SURGERY

CHARLES M. MCKENNA—9. Operative clinic: Plastic surgery on genitourinary tract.

Thursday

GENERAL SURGERY

B. J. FITZGERALD—10. Demonstration: Peripheral vascular disease.

OBSTETRICS AND GYNECOLOGY

CLYDE J. GEIGER—9. Operations: Gynecological.

Friday

GENERAL SURGERY

LEONARD A. KRATZ—9. Operations.
WILLIAM C. BECK—9. Penetrating and nonpenetrating wounds of abdomen.

MT. SINAI HOSPITAL

Tuesday

GENERAL SURGERY

V. L. SCHRAGER—9. Surgery of the stomach.

ORTHOPEDIC SURGERY

CHARLES M. JACOBS—2. Operations.

GENITOURINARY SURGERY

HARRY C. ROLNICK—9. Operations: Genitourinary.

OTOLARYNGOLOGY

M. R. GUTTMAN—9. Nasal plastics.

Wednesday

GENERAL SURGERY

JACOB LIFSCHUTZ—9. Endoscopic clinic.
J. M. MORA—9. Thyroidectomy.

OBSTETRICS AND GYNECOLOGY

A. E. KANTER—9. Operations: Gynecological.

Thursday

GENERAL SURGERY

D. A. WILLIS—9. New operation for inguinal hernia.

OBSTETRICS AND GYNECOLOGY

A. F. LASH—9. Operation: Vaginal hysterectomy.

OTOLARYNGOLOGY

S. M. MORWITZ—9. Operations.

Friday

GENERAL SURGERY

A. A. STRAUSS and S. F. STRAUSS—9. Operations: Stomach and colon.

OTOLARYNGOLOGY

EMIL AISON—9. Operations.

ST. MARY OF NAZARETH HOSPITAL

Tuesday

OBSTETRICS AND GYNECOLOGY

M. E. UZNANSKI—10. Operations.
A. S. SAMPOLINSKI—11. Operation: Vaginal hysterectomy.

Wednesday

OTOLARYNGOLOGY

F. J. PISZKIEWICZ—9. Operations.

Thursday

GENERAL SURGERY

T. M. LARKOWSKI—9. Operative clinic.
E. H. WARSZEWSKI—10. Operative clinic.
G. M. MUELLER—11. Operative clinic.

Friday

ORTHOPEDIC SURGERY

L. M. CZAJA—9. Operations.

VETERANS ADMINISTRATION FACILITY

Tuesday

GENERAL SURGERY

B. F. WARD, P. F. BROWN, and H. R. FELDOTT—9. Operative clinic.
R. B. MORELAND and R. A. THOMAS—9. Operations: Colon and rectal.

THORACIC SURGERY

JEROME R. HEAD and T. R. HUDSON—9. Operative clinic.

Wednesday

GENERAL SURGERY

B. F. WARD, H. R. FELDOTT, and H. U. STEPHENSON, JR.—9. Operative clinic.
MAX CUTLER, G. R. ALLABEN, and R. B. MORELAND—9. Tumor clinic: Presentation of cases, irradiation therapy.

ORTHOPEDIC SURGERY

W. P. SHERLOCK—9. Operations.

GENITOURINARY SURGERY

T. G. MCDOUGALL—9. Operations.

Thursday

GENERAL SURGERY

B. F. WARD, H. R. FELDOTT, and H. U. STEPHENSON, JR.—9. Operative clinic.
R. B. MORELAND and R. A. THOMAS—9. Operations: Tumor.

THORACIC SURGERY

JEROME R. HEAD and T. R. HUDSON—9. Operations.

Friday

GENERAL SURGERY

P. F. BROWN, B. F. WARD, and H. R. FELDOTT—9. Operative clinic.
R. B. MORELAND and R. A. THOMAS—9. Operations: Tumor.
G. R. ALLABEN and R. B. MORELAND—2. Tumor clinic: Diagnostic and treatment indications.

GENITOURINARY SURGERY

T. G. MCDOUGALL—9. Operations.

EVANGELICAL HOSPITAL

Tuesday

GENERAL SURGERY

JAMES PATEJDL—9. Operative and dry clinic.

Wednesday

GENERAL SURGERY

G. E. JOHNSON—9. Operative and dry clinic.

Thursday

GENERAL SURGERY

PERCY E. HOPKINS—9. Operative and dry clinic.
G. HENRY MUNDT—9. Ménière's syndrome.

RAVENSWOOD HOSPITAL

Tuesday

GENERAL SURGERY

Staff—8. Operations, demonstrations of anesthesia.
Staff—10. Round table discussion by members of the Tumor Clinic.

Wednesday

OBSTETRICS AND GYNECOLOGY

ARTHUR J. CHALOUPKA—8. Operation: Gynecological.
EDWARD F. FOX and ALBERT MICKOW—8. Operation: Gynecological.
Staff—10. Dry clinic: Obstetrical and gynecological.

ORTHOPEDIC SURGERY

DARWIN B. POND and associates—10. Dry clinic: Demonstration of cases.

Thursday

GENERAL SURGERY

JOSIAH J. MOORE—8. Pathological conference.

GENITOURINARY SURGERY

NORRIS J. HECKEL—10. Operations.

OPHTHALMOLOGY

Staff—2. Round table discussion:
ALFRED N. MURRAY. Eye injuries.
CHESTER H. LOCKWOOD. Strabismus; refraction.

OTOLARYNGOLOGY

Staff—2. Round table discussion:
WILLIAM J. NOONAN. Mastoids.
JOHN C. VERMEREN. Bronchoscopy.

ST. ANNE'S HOSPITAL

Wednesday

GENERAL SURGERY

J. J. GEARIN, E. P. GRAMER, J. W. KEANE, J. L. KNAPP, ADOLPH KRAFT, H. M. PETERSON, G. F. THOMPSON, and N. T. FRANCONA—9. Operative and dry clinic.
R. M. CASSIDY and L. R. HILL—9. Dry clinic: Radiology and pathology.

OBSTETRICS AND GYNECOLOGY

J. L. FLEMING and R. J. HAWKINS—9. Operative and dry clinic.

FRACTURES AND OTHER TRAUMAS

J. J. CALLAHAN and T. E. MEANY—9. Dry clinic.

OPHTHALMOLOGY

J. W. HAYDEN—9. Operative and dry clinic.

GENITOURINARY SURGERY

H. J. DOOLEY and C. C. SAELHOF—9. Operations.

OTOLARYNGOLOGY

J. W. HAYDEN—9. Operative and dry clinic.

COLUMBUS HOSPITAL

Days to be Announced

GENERAL SURGERY

J. L. SPIVACK. Wounds and injuries of the stomach.
H. L. DUVRIES. Deformities of the tarsus.
NATHAN FLAXMAN. Surgical vs. medical treatment of essential hypertension.
H. R. KENNY. Incisions.
DANIEL A. ORTH. Experimental thyrotoxicosis.
ERNEST NORA and P. G. PITCHIOS. Three cases of Cooley's anemia in one family, with a report on Rh agglutinins.

THORACIC SURGERY

MINAS JOANNIDES. Collapse therapy of pulmonary tuberculosis.

EVANSTON HOSPITAL

Wednesday

GENERAL SURGERY

FREDERICK CHRISTOPHER, M. H. HOBART, and E. C. TURNER—9. Operations.

FRACTURES AND OTHER TRAUMAS

DWIGHT F. CLARK—9. Fracture clinic.

ORTHOPEDIC SURGERY

R. C. LONERGAN—9. Operations.

GENITOURINARY SURGERY

JAMES I. FARRELL—9. Operations.

THORACIC SURGERY

JEROME R. HEAD—9. Operations.

OTOLARYNGOLOGY

THOMAS C. GALLOWAY, GLENN J. GREENWOOD, and H. C. BALLENGER—9. Nose and throat operations.

OPHTHALMOLOGY

GAIL R. SOPER—9. Eye operations.

ST. BERNARD'S HOSPITAL

Wednesday

GENERAL SURGERY

J. C. WALL—8. Demonstration: Practical inhalation anesthesia.
WILLIAM J. MULHOLLAND—9. Operations: Gall-bladder.
J. B. HAEBERLIN—9. Operations.
L. B. DONKLE—10. Hemorrhage, transfusion.
M. E. CREIGHTON—10. Operations: Pelvic.
DR. CUSHMAN and R. J. MAIER—10. Clinical radiation therapy, case demonstrations.
SAMUEL L. GOVERNALE—11. Injuries to lower extremity, case demonstrations.
WILLIAM P. GUNN—1. Operations.

OBSTETRICS AND GYNECOLOGY

DR. JACOPIK—8. Operations: Uterine.
DR. ROCK—9. Cesarean section.

FRACTURES AND OTHER TRAUMAS

WILLIAM G. EPSTEIN—2. Fractures of radius.

OPHTHALMOLOGY

CLIFFORD P. SULLIVAN—1. Eye injuries, case demonstrations.

CHICAGO LYING-IN HOSPITAL

Monday

OBSTETRICS AND GYNECOLOGY

Staff—2. Dry clinic.

Tuesday

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic.
Staff—2. Dry clinic.

Wednesday

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic.
Staff—2. Dry clinic.

Thursday

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic.
Staff—2. Dry clinic.

Friday

OBSTETRICS AND GYNECOLOGY

Staff—9. Operative clinic.
Staff—2. Dry clinic.

AUGUSTANA HOSPITAL

Tuesday

GENERAL SURGERY

NELSON M. PERCY and OSCAR E. NADEAU—9. Surgical clinic.

Wednesday

GENERAL SURGERY

A. T. LUNDGREN, EARL GARSIDE, JOHN W. NUZUM, and RUDOLPH J. ODEN—9. Surgical clinic.

Thursday

GENERAL SURGERY

NELSON M. PERCY and OSCAR E. NADEAU—9. Surgical clinic.